ENERGY REPORT

ENERGY ENGINEERING ANALYSIS PROGRAM

ENERGY SURVEY OF BOILER AND CHILLER PLANTS

YUMA PROVING GROUND, ARIZONA

19971016 040

PREPARED FOR

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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1.0 Executive Summary

1.1 Introduction

This report summarizes all work for the Energy Survey of Boiler and Chiller Plants, Energy Engineering Analysis Program (EEAP) at U.S. Army Yuma Proving Ground, Arizona, authorized under Contract DACA05-92-C-0155 with the U.S. Army Corps of Engineers, Sacramento District, California.

The purpose of this study is to develop projects and actions that will reduce facilities energy consumption and operating costs at Yuma Proving Ground. Implementation of these projects will contribute to achieving the goal of the Army Facilities Energy Plan of a reduction in energy consumption per square foot of building floor area of 20 percent by FY2000 from FY1985 baseline levels.

The survey and evaluation effort was limited to chillers and direct expansion cooling units in Buildings 451, 506, 2105, 3482, 3490, and 3510 and boilers in Building 506.

1.2 Energy Conservation Analysis

A summary of all potential energy conservation opportunities (ECOs) investigated is presented in Table 1-1. This table includes a matrix of reasons for eliminating ECOs from further consideration. A summary of analysis results for recommended ECOs is presented in Table 1-2, and a summary of analysis results for ECOs rejected is presented in Table 1-3.

1.3 ECIP Project Developed

An ECIP-qualifying project covering energy improvements in the surveyed facilities was developed that includes the following retrofit measures:

a. Replace two steam boilers with one modular hot water boiler system in Building 506.

b. Install chilled water temperature reset controls on three chillers (one in Building 506 and two in Building 2105).

c. Replace the converted 45-ton glycol chiller for ice-on-coil system at Building 506 with an efficient unit designed for cold temperature application.

d. Install duty cycling controls on four chillers (one in Building 451 and three in Building 3490).

e. Modify lighting fixtures and install lighting controls as follows:

(1) Retrofit fluorescent fixtures with electronic ballasts and T8 lamps in Buildings 451, 506A, 506B, 506C, 2105 and 3490.

(2) Retrofit 4-lamp fluorescent fixtures with 3-lamp electronic ballasts, T8 lamps and specular reflectors in Buildings 457, 506B, 2105 and 3490.

(3) Replace incandescent fixtures with surface mounted T8 and compact fluorescent fixtures in Buildings 451, 506A and 506B.

f. Install occupancy sensors (ceiling or wall-switch mounted) in Buildings 451, 506A, 506B, 2105 and 3490.

g. Install additional (explosion-proof) light fixture switching in Building 3482.

The following ECIP project data is taken from the DD Form 1391 life cycle cost analysis summary sheet (note that more up-to-date criteria and discount factors are used to prepare funding documents, thus, results may not be the same as presented in this report):

Construction cost (including SIOH, design and utility rebates) $632,257
Annual energy savings
• Electricity ....3,321 million Btu
• No. 2 fuel oil ....466 million Btu
• Liquified petroleum gas (LPG) ....578 million Btu
Annual dollar savings $119,952
Savings-to-investment ratio (SIR) 2.64
Simple payback period ....5.3 years
Analysis date ....January 1994

1.4 Conversion to Non-chlorofluorocarbon Refrigerants

In response to the production phaseout of CFCs and HCFCs as mandated by the Montreal Protocol, the scope of the study included an analysis of conversion to non-CFC refrigerants for the surveyed chillers. Recommendations to contain existing refrigerants, retrofit with HFC-type refrigerants, or completely replace chillers, along with associated costs, are summarized in Table 1-4.

Table 1-1
Summary of ECO Evaluations

No.	Description of ECO	SIR Greater Than 1.0	SIR Less Than 1.0	Recommended Project
	Building 506 Boiler Efficiency Improvements			
B1	High Efficiency Burners and O_2 Trim Controls	✓		
B2	Install Engineered Turbulators in Fire Tubes	✓		
B3	Automatic Boiler Blowdown with Heat Recovery	✓		
B4A	New Modular Boilers for Heating and Domestic Water	✓		✓
B4B	New Modular Boilers for Domestic Water Only		✓	
	Cooling Equipment ECOs			
	Chilled Water Temperature Reset (Buildings 506 C-1, 2105 C-1 and C-5)	✓		✓
	Chilled Water Temperature Reset (Buildings 451, 2105 C-2, 3490 C-1, C-2 and C-3)		✓	
	Replace Glycol Chiller at Building 506	✓		✓
	Electronic Expansion Valves (Buildings 3482 and 3510)		✓	
	Optimize Cooling Tower Control (Condenser Water Temperature)		✓	
	Manifold Chillers C-1, C-2 and C-3 at Building 3490	✓		✓
	Duty Cycling Controls, Demand Limiting	✓		✓
	Shading Air Cooled Condensers		✓	
	Evaporative Precooling		✓	
	Lighting and Control ECOs			
A	Retrofit: 1-Lamp Electronic Ballast and T8 Lamp	✓		Most
B	Retrofit: 2-Lamp Electronic Ballast and T8 Lamps	✓		✓
C	Retrofit: 3-Lamp Electronic Ballast and T8 Lamps	✓		✓
D	Retrofit: 4-Lamp Electronic Ballast and T8 Lamps	✓		Most
E	New Fixture: 1-Lamp Electronic Ballast and T8 Lamp		✓	
F	New Fixture: 2-Lamp Electronic Ballast and T8 Lamps	✓		Most
G	New Fixture: 3-Lamp Electronic Ballast and T8 Lamps — Explosion Proof		✓	
H	Retrofit: 3-Lamp Electronic Ballast and T8 Lamps and Specular Reflector	✓		✓
I	Retrofit: Occupancy Sensor Lighting Control — Ceiling Mounted	✓		✓
J	Retrofit: Occupancy Sensor Lighting Control — Auto. Wall Switch	✓		✓
K	New Fixture: 2-Lamp Compact Fluorescent, 2 x 13W/5T4	✓		✓
L	New Fixture: 2-Lamp Electronic Ballast and T8 Lamps, 2' Surface Mount	✓		✓
M	Install Switching for Assembly Rooms — Building 3482	✓		✓

Notes: Only one Boiler Efficiency project group may be implemented: (B1, B2 and B3), B4A or B4B. B4A is recommended.

Lighting and control ECOs where recommendations are shown as "Most" are evaluated separately for each building; buildings in which the ECOs show SIRs > 1 are recommended.

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Table 1-2
Recommended Energy Conservation Opportunities

Project Number	/ Description	Electric Savings kW	Electric Savings kWH/Yr	Fuel MBTU/Yr Distillate	Fuel MBTU/Yr LPG	Energy Cost Saved $/Year	Energy Cost Saved LCC $	O&M Cost Saved $/Year	O&M Cost Saved LCC $	Investment $	Economic Measures SIR	Economic Measures Payback	Economic Measures AIRR
Recommended Building 506 Boiler Efficiency Improvement Projects													
B1	New Burners & O2 Trim	-	-	330	346	$6,923	$87,045	($1,320)	($14,177)	$62,241	1.17	11.1	5.6%
B2	Engineered Turbulators	-	-	164	163	$3,371	$42,346	($519)	($5,574)	$2,186	16.8	0.8	26.1%
B3	Auto-Blowdown w/ Heat Recovery	-	-	3	2	$49.61	$622	$6,798	$73,011	$16,302	4.27	2.4	15.6%
Totals for B1, B2 & B3		-	-	497	511	$10,344	$130,013	$4,959	$53,260	$80,728	2.27	5.28	10.4%
B4A	Modular Boilers for Heating & DHW	-	-	466	578	$10,435	$131,662	$17,820	$191,387	$122,560	2.64	4.3	11.5%
B4B	Modular Boilers for DHW Only	-	-	200	247	$4,467	$56,354	($1,980)	($21,265)	$73,923	0.47	29.7	-0.6%

Note: Boilers in building 506 are dual fueled, alternating between No. 2 Fuel Oil (Distillate) and LPG; boilers serve building 506 only.

Recommendation:
Implement B4A - Each of the above project groupings are mutually exclusive, e.g., project B4A cannot be economically justified if the group of B1, B2 & B3 are implemented.

Project / Description	Electric Savings kW	Electric Savings kWH/Yr	Fuel MBTU/Yr Distillate	Fuel MBTU/Yr LPG	Energy Cost Saved $/Year	Energy Cost Saved LCC $	O&M Cost Saved $/Year	O&M Cost Saved LCC $	Investment $	SIR	Payback	AIRR
Recommended Cooling Equipment Energy Conservation Opportunities Evaluated												
Chilled Water Temperature Reset (506 C-1, 2105 C-1 & C-5)	-	146,584	-	-	$12,166	$137,481	($1,584)	($17,012)	$30,304	3.98	2.86	14.6%
Replace Glycol Chiller 506 C-2	-	80,000	-	-	$6,640	$75,032	-	-	$62,606	1.20	9.43	5.8%
Manifold Chillers C-2 & C-3 at Building 3490	-	92,825	-	-	$7,704	$87,060	($1,320)	($14,177)	$57,321	1.27	8.98	6.2%
Duty Cycling Controls	36.8	-	-	-	$1,164	$13,157	($132)	($1,418)	$6,524	1.80	6.32	8.7%
Total of Recommended Cooling Equipment ECOs	36.8	319,409	-	-	$27,675	$312,730	($3,036)	($32,606)	$156,755	1.79	6.36	8.6%

Project	Description	Electric Savings kW	Electric Savings kWH/Yr	Fuel MBTU/Yr Distillate	Fuel MBTU/Yr LPG	Energy Cost Saved $/Year	Energy Cost Saved LCC $	O&M Cost Saved $/Year	O&M Cost Saved LCC $	Investment $	SIR	Payback	AIRR
Recommended Lighting & Control Energy Conservation Opportunities Evaluated													
A	1-Lamp Electronic Ballast & T8 Lamp (2105S1 & 506A)	2.0	13,893	-	-	$1,153	$13,031	($104)	($1,115)	$7,885	1.51	7.51	7.4%
B	2-Lamp Electronic Ballast & T8 Lamps	50.3	213,214	-	-	$17,697	$199,973	($1,590)	($17,073)	$119,000	1.54	7.39	7.5%
C	3-Lamp Electronic Ballast & T8 Lamps	18.2	72,093	-	-	$5,984	$67,616	($602)	($6,463)	$36,991	1.65	6.87	8.1%
D	4-Lamp Electronic Ballast & T8 Lamps (506A & C)	2.3	7,868	-	-	$653	$7,379	($72)	($770)	$5,398	1.22	9.29	5.9%
F	2-Lamp Electronic Ballast & T8 Lamps (506B)	10.5	35,226	-	-	$2,924	$33,039	$6,132	$65,854	$32,560	3.04	3.60	12.5%
H	3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector	20.9	75,626	-	-	$6,277	$70,930	($109)	($1,176)	$34,379	2.03	5.57	9.5%
I	Ceiling Mounted Sensor Switch (2105, 3490, 506)	-	76,063	-	-	$6,313	$71,340	$0	$0	$31,097	2.29	4.93	10.4%
J	Automatic Wall Sensor Switch (451, 3490, 2105)	-	61,408	-	-	$5,097	$57,594	$0	$0	$20,560	2.80	4.04	11.9%
K	2-Lamp Compact Fluorescent 2 x 13W/5T4	4.1	16,076	-	-	$1,334	$15,078	$1,003	$10,769	$13,573	1.90	5.81	9.1%
L	2-Lamp Elect. Ballast & T8 Lamps, 2' Surface Mount	15.5	51,587	-	-	$4,282	$48,384	$8,138	$87,399	$36,279	3.74	2.92	14.1%
M	Install Light Switching for Assembly Rooms - Bldg 3482	-	30,680	-	-	$2,546	$28,775	$0	$0	$15,220	1.89	5.98	9.0%
Total of Recommended Lighting & Control ECOs		123.6	653,735	-	-	$54,260	$613,138	$12,796	$137,425	$352,942	2.13	5.27	9.9%
GRAND TOTAL OF RECOMMENDED ECOs		160.4	973,144	466	578	$92,370	$1,057,630	$27,580	$296,205	$632,257	2.14	5.27	9.9%

Includes Project B4A only from Boiler Efficiency Improvements

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Table 1-3
Energy Conservation Opportunities Not Recommended

Project Number	/ Description	Electric Savings kW	Electric Savings kWH/Yr	Energy Cost Saved $/Year	Energy Cost Saved LCC $	O&M Cost Saved $/Year	O&M Cost Saved LCC $	Investment $	Economic Measures SIR	Economic Measures Payback	Economic Measures AIRR
Cooling Equipment Energy Conservation Opportunities Not Recommended											
	Chilled Water Temperature Reset (451, 2105 C-2, 3490)	-	8,225	$683	$7,712	-	-	$50,505	0.15	73.98	-7.81%
	Optimize Cooling Tower Control (Condenser Water Temperature Reset)	Project not recommended because none of the chilled water systems evaluated is large enough.									
	Shade Air Cooled Condensers from Sunlight	Project not recommended: all but 1 A/C chiller are located on the North sides of their buildings.									
	Evaporative Precooling of Air Cooled Condenser Air	Project not recommended because life cycle energy cost savings are less than the investment.									
Lighting & Control Energy Conservation Opportunities Not Recommended											
A	1-Lamp Electronic Ballast & T8 Lamp (2105N,S2 & 3490)	0.90	3,567	$296	$3,345	($31)	($334)	$4,284	0.70	16.17	2.07%
D	4-Lamp Electronic Ballast & T8 Lamps (2105S2 & 506B)	1.11	3,075	$255	$2,884	($101)	($1,083)	$2,976	0.61	19.27	1.06%
E	New Fixture for Lighting ECO A (451,506, 2105 & 3490)	2.74	10,806	$897	$10,135	($80)	($863)	$46,326	0.20	56.74	-6.13%
F	2-Lamp Electronic Ballast & T8 Lamps (451)	0.30	1,099	$91	$1,031	$170.6	$1,832	$3,706	0.77	14.15	2.72%
G	3-Lamp Elect. Bal. & T8 Lamps - Explosion Proof (3482 & 3510)	28.91	64,242	$5,332	$60,253	$2,155	$23,140	$632,295	0.13	84.46	-8.70%
I	Ceiling Mounted Sensor Switch (506A)	0.00	3,847	$319	$3,608	$0	$0	$7,323	0.49	22.94	-0.32%
J	Automatic Wall Sensor Switch (506A & B)	0.00	19,999	$1,660	$18,758	$0	$0	$40,890	0.46	24.63	-0.79%

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Table 1-4
Non-Chlorofluorocarbon Refrigerant Conversion Recommendations (1)

Building Number	Unit Description (2)	Contain Refrigerant	Replace Refrigerant	Replace Unit	Recommended Investment (3)	Explanation
451	55 Ton A/C Reciprocating Chiller	**$ 12,500**	-	$ 60,574	$ 14,000	Unit is now only 7 years old. Contain refrigerant until a replacement unit is needed.
506	220 Ton W/C Centrifugal Chiller C1	$ 12,500	$ 17,680	**$ 159,424**	$ 178,555	Unit is now 20 years old and is due for replacement at this time.
506	45 Ton A/C Reciprocating Glycol Chiller C2	$ 12,500	-	**$ 55,898**	$ 62,606	Analysis shows that replacing this unit now is the most cost effective choice.
2105	125 Ton W/C Centrifugal Chiller C1	$ 12,500	$ 16,728	**$ 145,558**	$ 163,025	Unit is now 17 years old and is due for replacement at this time.
2105	40 Ton W/C Reciprocating Chiller C2	$ 12,500	-	**$ 46,792**	$ 52,408	Unit is now 17 years old and is due for replacement at this time.
2105	125 Ton W/C Centrifugal Chiller C5	**$ 12,500**	$ 16,728	$ 145,558	$ 14,000	Unit is only 10 years old. Contain refrigerant until a replacement unit is needed.
3482	62 Ton W/C Reciprocating DX Unit	$ 12,500	-	**$ 53,992**	$ 60,471	Unit is now 24 years old and is due for replacement at this time.
3490	25 Ton A/C Reciprocating Chiller C1	**$ 12,500**	-	$ 32,138	$ 14,000	Unit is now only 7 years old. Contain refrigerant until a replacement unit is needed.
3490	50 Ton A/C Reciprocating Chiller C2	**$ 12,500**	-	$ 57,312	$ 14,000	Unit is now only 7 years old. Contain refrigerant until a replacement unit is needed.
3490	100 Ton A/C Reciprocating Chiller C3	**$ 12,500**	-	$ 112,800	$ 14,000	Unit is now only 7 years old. Contain refrigerant until a replacement unit is needed.
3510	40 Ton W/C Reciprocating DX Unit	**$ 12,500**	-	$ 38,932	$ 14,000	Unit was converted to HFC-134a in 1993. Retrofit refrigerant containment equipment.
Total Probable Construction Cost					**$ 601,064**	

Notes:
1. Recommended options are displayed in **Bold-Face** type.
2. Condenser types: A/C = Air Cooled; W/C = Water Cooled
3. Investment includes construction costs plus 6% for SIOH and 6% for design.

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2.0 Introduction

This report contains the results of all work to date for the Energy Survey of Boiler and Chiller Plants, U.S. Army Yuma Proving Ground, Arizona. The work was authorized under Contract Number DACA 05-92-C-0155 with the U.S. Army Corps of Engineers, Sacramento District, Sacramento, California.

2.1 Purpose

The purpose of this energy survey is to develop projects and actions that will reduce energy consumption and operating costs of selected boiler and chiller plants at Yuma Proving Ground.

2.2 Scope

The scope of work, as established by the U.S. Army Corp of Engineers, Sacramento District, consists of the following tasks:

- Site investigation including efficiency testing of (a) chillers in Buildings 451, 506, 2105, 3482 and 3490; (b) a direct expansion cooling unit in Building 3510; and (c) two boilers in Building 506.
- Survey of lighting systems in Buildings 451, 506, 2105, 3482 and 3490.
- Review of previously completed chiller plant studies.
- Determination of efficiencies of the surveyed chiller and boiler plants.
- Evaluation of specific energy conservation opportunities (ECOs) to determine economic feasibility.
- Evaluation of the impact of conversion to non-chlorofluorocarbon refrigerants for the cooling equipment included in the survey.
- Evaluations of the feasibility of monitoring and controlling the surveyed boiler and chiller plants with a new, or expanded, energy monitoring and control system (EMCS).
- Preparation of funding documentation for recommended ECOs.
- Preparation of a comprehensive report documenting the data collected, analysis performed and projects recommended.

The complete scope of work, together with minutes of the pre-negotiation conferences is provided in Appendix A.

2.3 Methodology

The sequence of this study, in chronological order, progressed from the site investigation to the interim report preparation to the pre-final and final report preparation. Methodologies used at each phase of the study are addressed as follows:

2.3.1 Site Investigation

An entry briefing attended by the architect/engineer, representatives of Yuma Proving Ground Directorate of Engineering and Housing (DEH) and a representative of J&J Corporation, the site operations and maintenance contractor, was held prior to beginning the site inspection. Survey schedules and support requirements from DEH were discussed during this briefing.

Field team members then installed data monitoring and logging equipment at each chiller plant included in the study to record electric power inputs and chilled water flows and temperatures. The following data monitoring and logging equipment was used in the chiller plant investigation:

- Data Loggers: John Fluke Model 2286A
- Electric Power/Demand Analyses: Dranetz Model 808
- Ultrasonic Flowmeters (Non-Invasive): Dynasonics Model M3-902-UP

Copies of available chiller plant and boiler plant as-built drawings, as well as building lighting plans were collected.

An exit briefing was held at the completion of the field work.

2.3.2 Interim Report

The first step in the preparation of the Interim Report was downloading of the chiller performance data from the data logger floppy disks. Curves of input energy demand, output cooling BTUH and calculated energy efficiency ratios (ERRs) were then created from the recorded data.

Following the determination of chiller and boiler plant efficiencies, potential energy conservation opportunities (ECO) identified during the field survey and in the Scope of Work were evaluated for each study chiller, boiler and building lighting system. Spreadsheet software and, where necessary, manual calculations were employed to determine the relative benefits of each ECO. Life cycle cost analyses were performed for all ECOs in accordance with the latest "Energy Conservation Investment Program (ECIP) Guidance."

The results of the ECO analyses were summarized into two listings as follows:

(1) All ECOs that were analyzed and recommended, arranged in order of descending savings-to-investment ratio (SIR).

(2) All ECOs that were analyzed and not recommended, arranged in order of descending SIR.

2.3.3 Prefinal and Final Reports

Following the Interim Report presentation and review conference, funding documents will be prepared for combinations of viable ECOs as directed by the Government review. In addition, revisions resulting from the review conference will be incorporated into these documents. For all projects with SIRs greater than 1.25, the following funding categories will apply:

- ECIP Project: Construction cost greater than $300,000 and simple payback period less than 10 years.
- Regular Military Construction, Army (MCA) Program: Construction cost greater than $300,000 and simple payback period of 10 years and greater.
- Low Cost/No Cost projects: Projects that Yuma Proving Ground DEH can perform with in-house resources or by contract.

3.0 Description of Installation

3.1 General Site Data

U.S. Army Yuma Proving Ground is located in the southwest corner of Arizona, approximately 20 miles northeast of Yuma. A general location map is provided on Figure 3-1.

The summer design dry and wet bulb temperatures are 109 degrees F and 71 degrees F, respectively. These are the temperatures equalled or exceeded 2 1/2 percent of the time, on the average, during the warmest four consecutive months (June through September). The dry bulb temperature exceeds 80 degrees F an average of 3,185 hours per year and the wet bulb temperature exceeds 67 degrees F an average of 1,838 hours per year during the six warmest months of the year. Cooling degree days (the difference between the mean daily temperature and a base temperature of 65 degrees F as listed in TM5-785) total 4,261 annually.

The winter design dry bulb temperature is 39 degrees F. This temperature is equalled or exceeded 2-1/2 percent of the time, on the average, during the coldest consecutive three months (December through February). Heating degree days (the difference between the mean daily temperature and a base temperature of 65 degrees F as listed in TM5-785) total 968 annually.

3.2 Chiller Plants

All of the study buildings are air conditioned and employ mechanical refrigeration. Each building has a unique system configuration. Chilled water and direct expansion units serving each of the study buildings are summarized on Table 3-1. Data collected during field investigations of each system is provided in Appendix B.

3.2.1 Building 451 Chiller

Building 451, the Cactus Club, is served by a 55 ton, air cooled chiller with reciprocating compressors. Chilled water is pumped from the chiller to cooling coils in air handling units which serve the building. The chilled water system is shown on Figure 3-2. The Cactus Club is open every day for dining and special community events.

3.2.2 Building 506 Chillers

Building 506 is a two-wing, three-floor enlisted persons barracks with dining facility. Some of the building has been converted to administrative functions and the dining facility is not in use. Soldiers presently use other facilities on site for dining, including the Community Club and Cactus Club.

Building 506 is served by a 220 ton water cooled centrifugal chiller and an ice-on-coil Diurnal Ice Storage Cooling System. The ice-on-coil system is used during peak electrical demand periods as a load-shedding device. This developmental thermal storage system includes an air-cooled

ice storage system during the remainder of the day (the peak electrical demand period). A schematic flow diagram is shown on Figure 3-3.

3.2.3 Building 2105 Chillers

Building 2105, the Yuma Proving Ground Range Operations Center, is cooled by air handling units fitted with chilled water cooling coils. Chilled water is generated by a complex system consisting of two 125 ton water cooled centrifugal chillers, a 40 ton water cooled reciprocating chiller and a 165 ton absorption chiller. The thermal source for the absorption chiller consists of a field of tracking type solar collectors. A flow diagram of the chilled water system is shown on Figure 3-4.

When available, the solar absorption chiller is used during peak electrical demand periods to reduce energy costs. Other chillers are brought on line as capacity is required. The 40 ton and 125 ton chillers and the absorption chiller are served by three interconnected cooling towers. Chiller C-5 is served by a separate cooling tower. Cooling is provided 24 hours per day; the Range Operations Center is in continuous use.

3.2.4 Building 3482 Cooling System

Building 3482, the Test Preparation Facility, is served by a multi-zone air handling unit. Cooling is provided by direct expansion (DX) coils. A 62 ton water cooled condenser and reciprocating compressor provide refrigerant to the DX coils. Due to the explosive nature of the substances handled in this facility, the air handling system is once-through; no return air enters the multi-zone air handling unit. A system schematic is shown on Figure 3-5. This building is normally in use for only 40 hours per week; however, heating, ventilating and air conditioning (HVAC) systems are operated continuously.

3.2.5 Building 3490 Chillers

Building 3490, the Test Evaluation Facility, houses the Gun Shop and administrative offices on either side of a high-bay vehicle maintenance-type facility. The gun shop and administrative offices are air conditioned; the high-bay area is not. Chilled water provides cooling. Three air cooled chillers with reciprocating compressors serve the building.

A 25 ton unit serves the office wings located on the building's south side. Two chillers, a 50 ton and 100 ton unit, serve the gun shop, storage rooms and facilities on the building's north side. A small roof-top type cooling unit serves an electronics room located inside the gun shop area. Figure 3-6 shows the building's chilled water distribution system.

3.2.6 Building 3510 Cooling System

Building 3510 is a three-bay above ground storage magazine. Each bay has a dedicated air handling unit. Cooling is provided by a combination of water cooling coils served by cooling tower water, an air (water spray) washer and by DX cooling coils. Mechanical cooling is provided by a 40 ton reciprocating compressor recently converted to HFC-134a. A schematic flow diagram of the HVAC system in this building is provided on Figure 3-7.

3.3 Boiler Plant

The only boiler plant included in this energy survey consists of two steam boilers in Building 506. The steam boilers are sized to serve Building 506 space and domestic hot water heating needs via heat exchangers. In addition, the boilers are also designed to provide steam to dining facility cooking and dish-washing equipment. The old 4,315 pound per hour boilers have been well maintained, and controls were recently replaced.

The plant is oversized for current building use. Less than half the design population reside in the building and the dining facility has been shut down. This causes the boilers to cycle frequently.

The boilers are fired with both liquified petroleum gas (LPG) and No. 2 fuel oil. Fuel consumption for FY93 is shown in Appendix C. About the same amount of each fuel type was used during this year.

Table 3-1
Summary of Energy Survey Chillers

Bldg No.	Unit Description	Capacity (Tons)	Manufacturer	Refrigerant	Built (Year)	Condition
451	A/C Reciprocating	55	Carrier	R-22, 136 lbs.	1987	Good
506	W/C Centrifugal	220	Trane	R-11, 450 lbs.	1974	Good
506	A/C Reciprocating — Glycol(1)	45	Trane	R-22 (Rebuilt)	1988	Good
2105	C-1 W/C Centrifugal	125	Trane	R-113, 415 lbs.	1977	Good
2105	C-2 W/C Reciprocating	40	Trane	R-22, 55 lbs.	1977	Good
2105	C-5 W/C Centrifugal	125	Carrier	R-11	1984	Good
3482	W/C Reciprocating — DX	62	Carrier	R-22	1970	Good
3490	C-1 A/C Reciprocating	25	Webster	R-22	1987	Good
3490	C-2 A/C Reciprocating	50	Webster	R-22	1987	Good
3490	C-3 A/C Reciprocating	100	Webster	R-22	1987	Good
3510	W/C Reciprocating — DX	40	Trane	HFC-134a(2)	1993	Good

A/C: Air-Cooled W/C: Water-Cooled DX: Direct Expansion Unit

Notes:
1. The 45 Ton glycol chiller installed on building 506 serves the ice-on-coil system and was retrofitted from a water chiller, previously rated at 80 Tons.
2. The compressor serving the building 3510 cooling system was rebuilt in 1993. System is presently in good condition. Conversion to HFC-134a included refrigerant only; seals were not replaced.

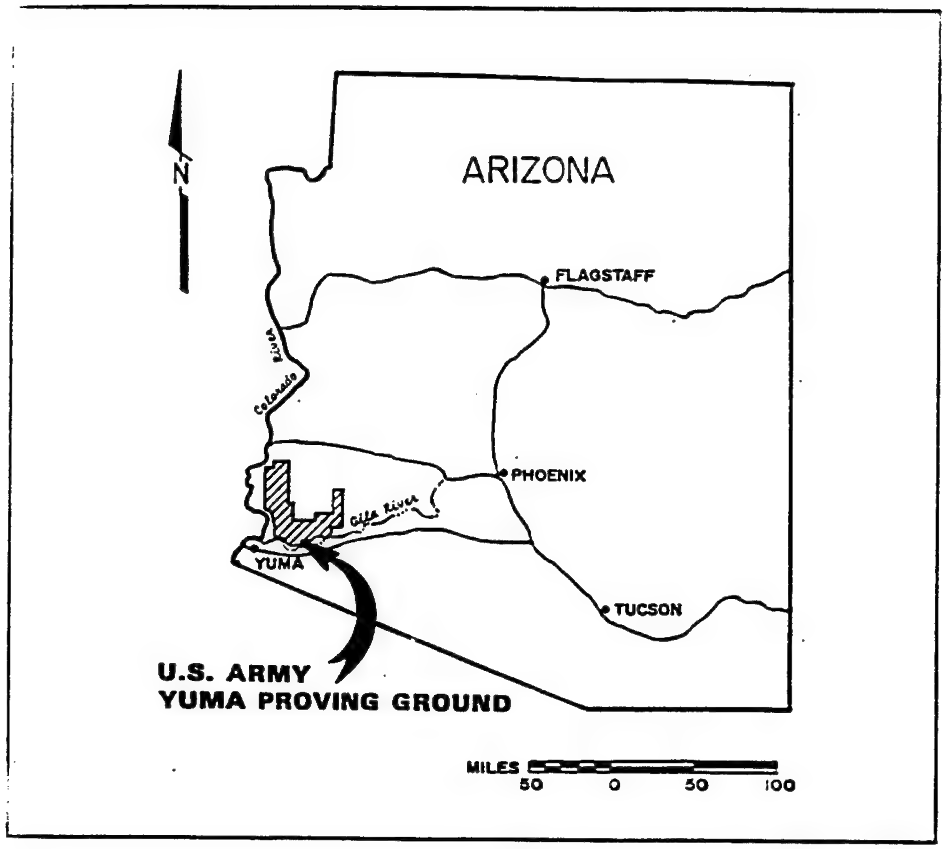

Figure 3-1. Yuma Proving Ground General Location Map

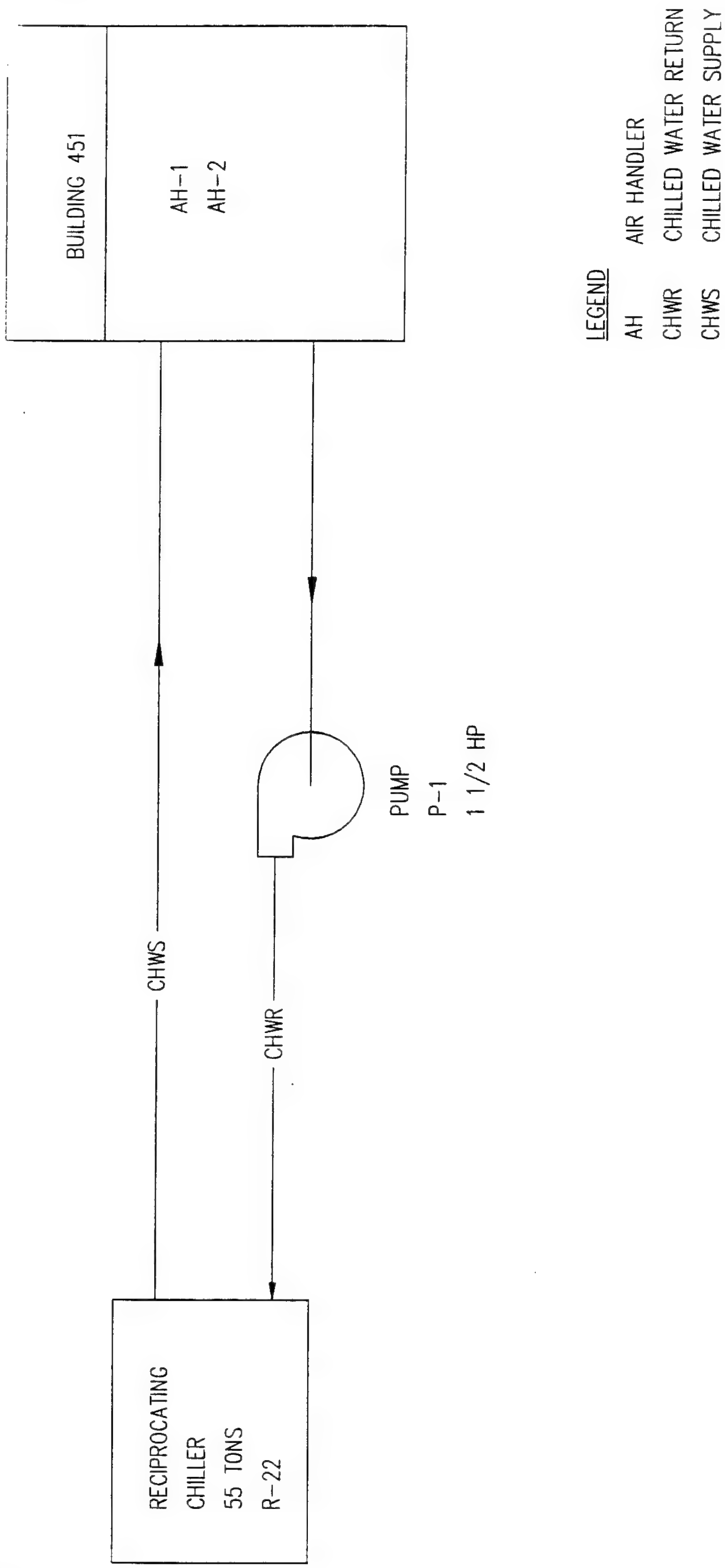

Figure 3-2. BUILDING 451 CHILLED WATER FLOW DIAGRAM

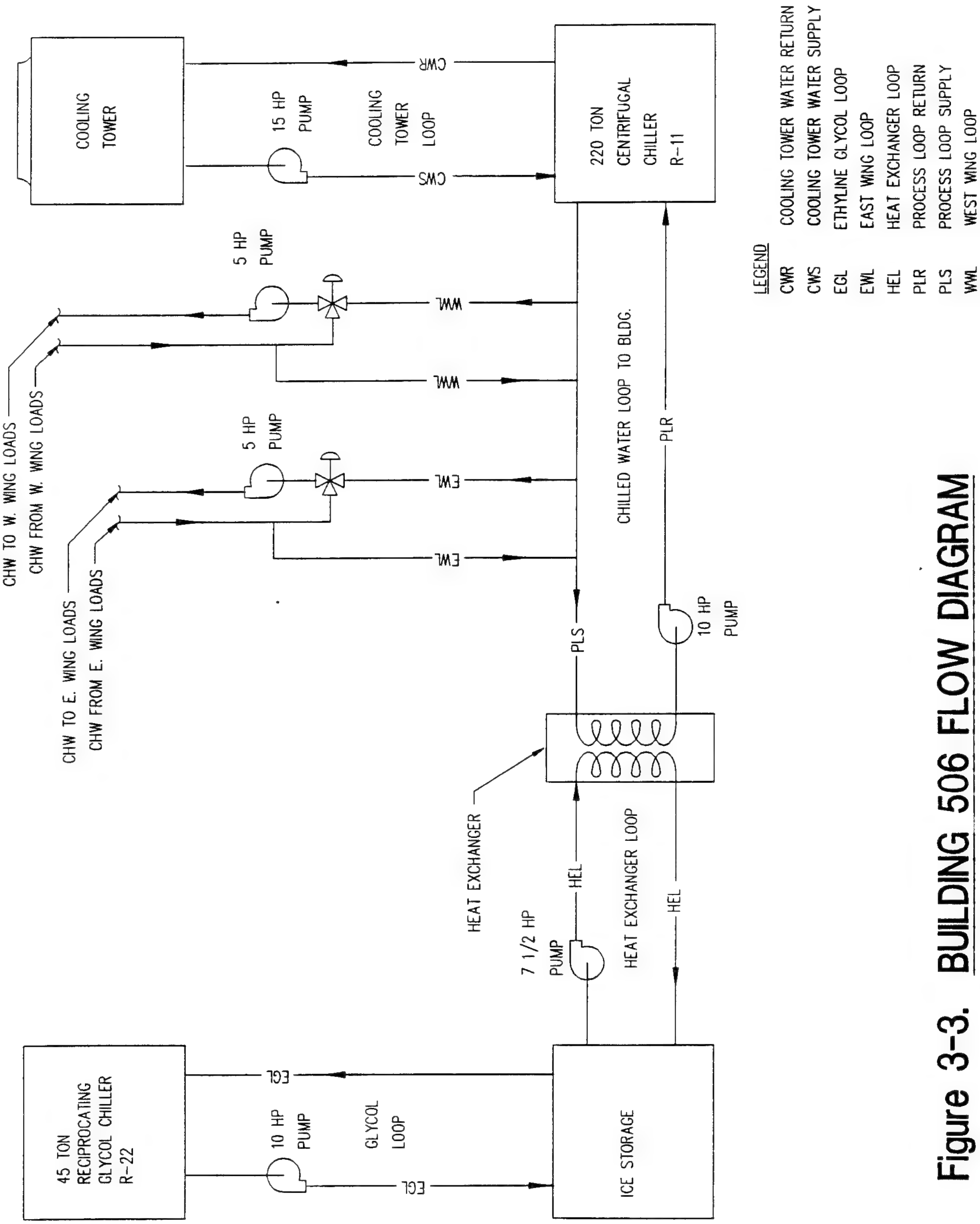

Figure 3-3. BUILDING 506 FLOW DIAGRAM

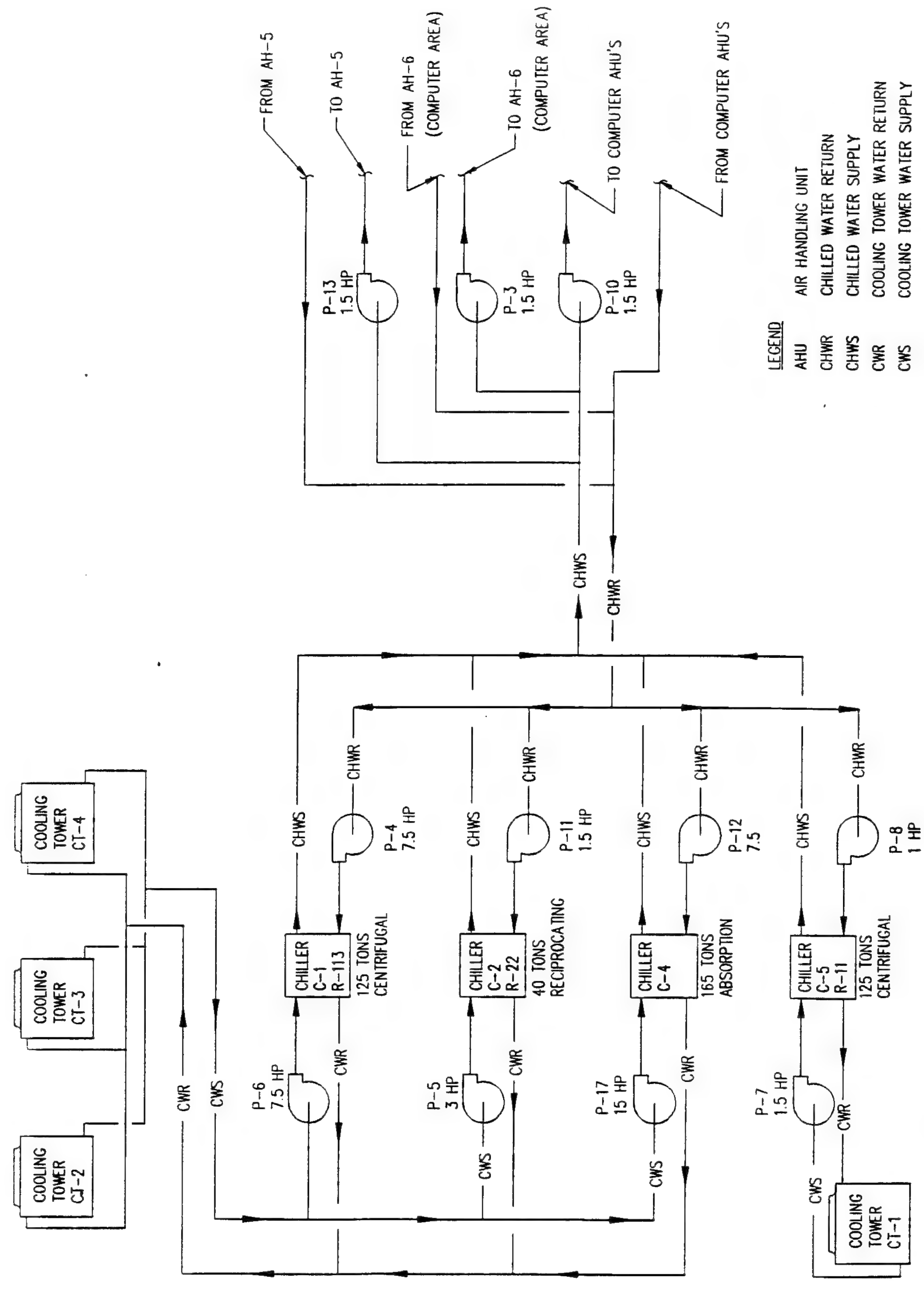

Figure 3-4. BUILDING 2105 CHILLED WATER FLOW DIAGRAM

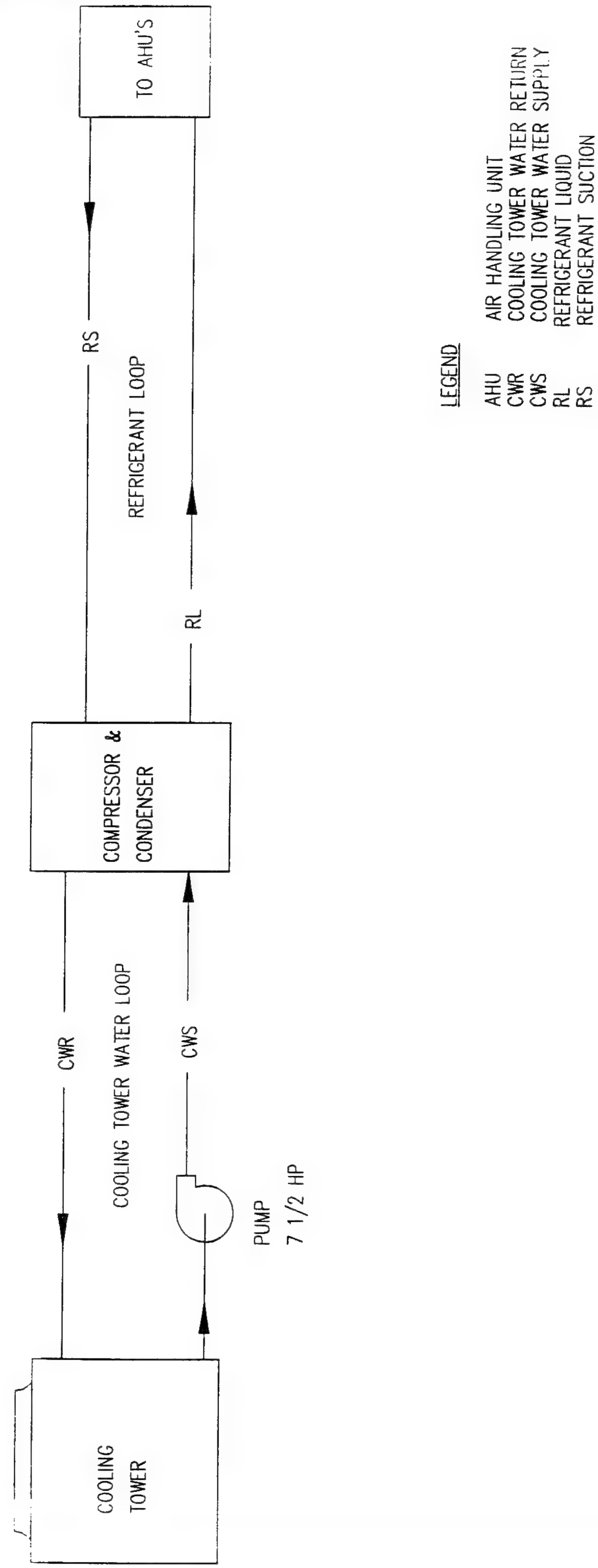

Figure 3-5. BUILDING 3482 FLOW DIAGRAM

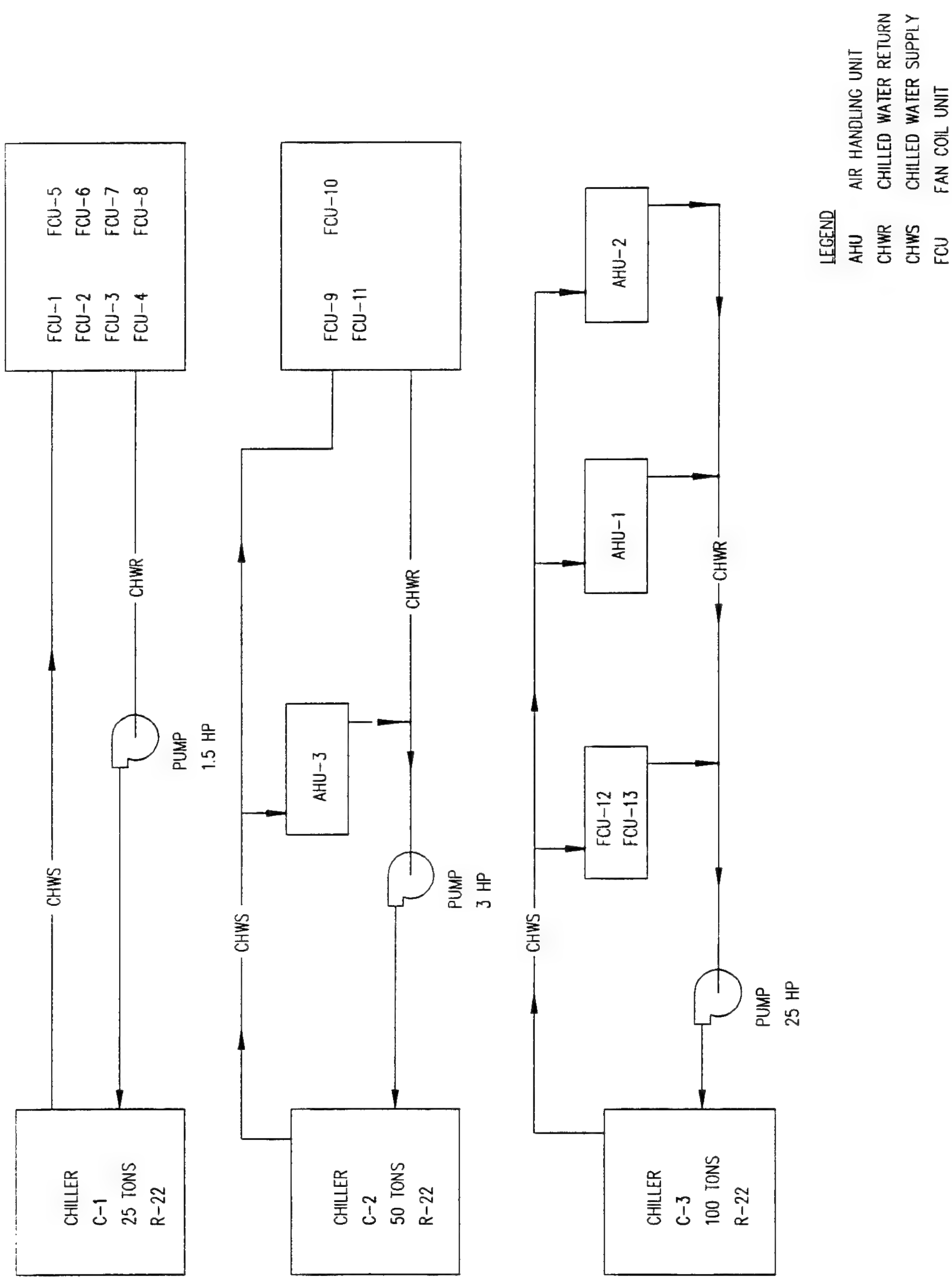

Figure 3-6. BUILDING 3490 CHILLED WATER FLOW DIAGRAM

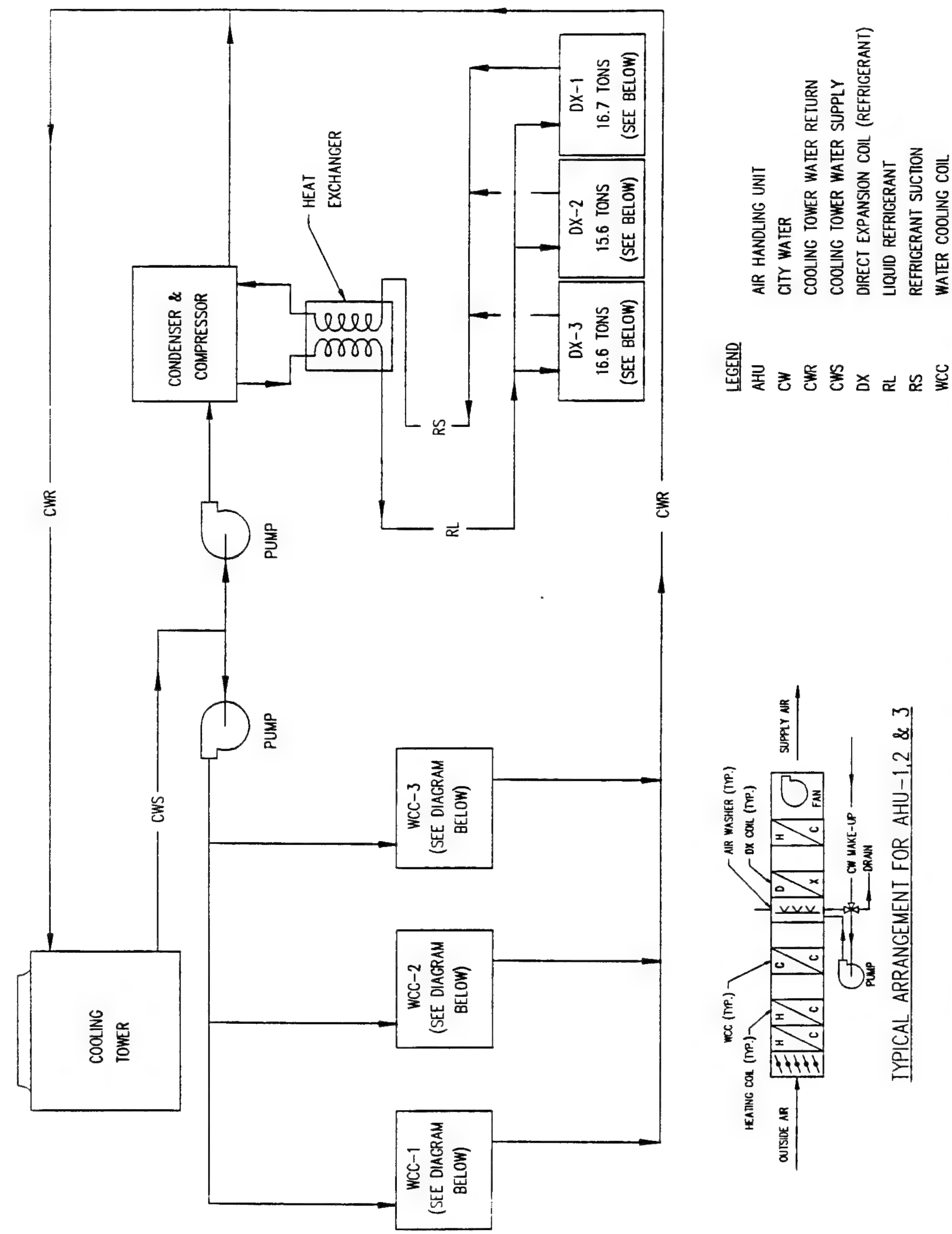

Figure 3-7. BUILDING 3510 FLOW DIAGRAM

4.0 Energy Conservation Evaluations

4.1 Life Cycle Cost Analysis Assumptions

4.1.1 Economic Assumptions

Economic analyses based on present value techniques were performed for all potential energy conservation opportunities using the economic analysis form and procedures outlined in "Energy Conservation Investment Program (ECIP) Guidance" dated November 1992. The following assumptions and methods were used to develop standard input for economic analysis of all projects:

a. Investment costs include the following: Construction costs; contingency estimated at 10% of construction costs; supervision, inspection and overhead (SIOH) at 6% of construction costs; and design at 6% of construction costs. Total investment is the sum of the above costs reduced by the amount of the expected utility rebate, if applicable.

b. Economics were analyzed using current (second quarter FY94) costs.

c. Discount factors and uniform present value factors used in computing present values are obtained from the supplement to NIST Handbook 135: Energy Prices and Discount Factors for Life-Cycle Cost Analysis 1994. The discount rate set for 1994 by the Department of Energy is equal to a market rate of 7%. Assuming a rate of general price inflation yields a "real" discount rate of 3.1%. Uniform present value factors (UPV) using the 4.5% discount rate and adjusted for average fuel price escalation in the industrial sector for Census Region 4 are used in the analyses below.

d. The present value of recurring non-energy cash flows was obtained using a 0% differential rate and 4.5% for projects. (Economic lives greater than 10 years.

e. Programming documents are provided following more up-to-date criteria. The latest ECIP guidance and life cycle cost analysis discount factors dated October 1993 from NIST were used. Thus, the same analyses in the report and programming document portions of this submittal may differ.

4.1.2 Energy Cost Assumptions

4.1.2.1 Electricity

The overall average cost of electric power purchased from five separate services by Yuma Proving Ground is $0.05 per kWH, including both demand and consumption charges. However, energy saved as a result of the implementation of retrofit projects will be used to reduce Arizona Public Service Company (APS) billings only. Therefore, the savings determined in the energy

conservation opportunity (ECO) analyses is the incremental cost of electricity to the Yuma Proving Ground. The most expensive source is from APS at $0.083 per kWH ($24.32 per million BTUs at 3,416 BTUs per kWH) including demand and energy use charges.

Another of the power suppliers to the YPG is the Western Area Power Authority (WAPA). Their relatively low demand charge is $1.98 per kW-month. However, a penalty of ten times this amount is charged whenever YPG's allocated demand is exceeded.

4.1.2.2 No. 2 Fuel Oil

The overall cost of delivered No. 2 fuel oil is $1.83778 per gallon ($13.25 per million BTUs at 138,700 BTUs per gallon) which includes distribution costs plus capitalization of fuel receiving and dispensing equipment.

4.1.2.3 Liquified Petroleum Gas (LPG)

The cost of LPG is $0.70 per gallon, or $7.37 per million BTUs at 95,000 BTUs per gallon.

4.1.2.4 Water

Potable water currently costs $2.77288 per 1,000 gallons, and non-potable water currently costs $0.201291 per 1,000 gallons.

4.2 Construction Cost Estimate Methodology

Construction costs are estimated for each energy conservation opportunity evaluated. Cost estimates may be considered at an order-of-magnitude level of accuracy. Labor and material costs are based predominantly on the 1994 Means Cost Estimating Guides with adjustments for geographic location and difficulty of retrofit work, as appropriate. Whenever feasible, budget quotes from equipment manufacturers have been used to improve accuracy.

Factors added to the subtotal of labor and materials costs include:

- Arizona Sales Tax at 5.5% (added to materials cost only)
- Contractor Overhead and Profit at 30%
- Bond at 1%
- Estimating Contingency at 10%

The resulting total probable construction costs are subsequently used in life cycle cost analyses.

4.3 Utility Rebate Programs

Arizona Public Service Company (APS) currently operates an incentive program for customers to install new high-efficiency electric chillers or to retrofit existing chillers for efficiency improvement. This program applies only to chillers 200 tons and larger, thus eliminating all

chillers included in the study except one 220 ton unit in Building 506. APS will pay $20 per ton rebate for a new high efficiency electric chiller using CFC-free refrigerants HCFC-22 or HCFC-123 and $30 per ton rebate for a new chiller using HFC-134a. These rebate amounts would be adjusted based on the percentage of the overall Yuma Proving Ground electric power requirement actually supplied by APS.

Lighting retrofit projects that reduce electrical demand will qualify for $8.15 per kW reduction. This rebate level results from applying the percentage of total Yuma Proving Ground electrical power requirements supplied APS (8.15%) to the 100% customer rebate of $100 per kW saved. Rebate awards are limited to a maximum of $25,000.

4.4 Energy Conservation Opportunities Studied

Energy conservation opportunities (ECOs) are developed and evaluated for study buildings and include the following categories of projects:

- Boiler efficiency improvements for building 506
- Cooling equipment efficiency improvements
- Lighting system fixture and control retrofits

Results of analyses are summarized on Table 4-1.

4.4.1 Building 506 Boiler Plant

The following ECOs are evaluated for the boiler plant in Building 506. These boilers are fired alternately on No. 2 fuel oil and LPG; one fuel is always standby.

<u>Project B1 — High Efficiency Burners Including Oxygen Trim Controls</u>: Replacing existing older burners with high efficiency burners and adding oxygen trim controls to the two steam boilers will provide an improvement in firing (combustion) efficiencies to 83% for No. 2 fuel oil and 75% for LPG from current firing efficiencies of 69% and 61%, respectively.

The life cycle cost analysis of this project yields a positive recommendation. However, if the boiler replacement project (B4) is implemented, this project would no longer be applicable.

<u>Project B2 — Turbulators</u>: Engineered turbulators installed in fire tubes cause combustion gases to pass through tubes with greater turbulence than do the short "spinners" normally installed as standard equipment. This greater turbulence improves heat transfer, thus increasing boiler efficiency up to 15%. Based on results of the economic analysis, this retrofit is recommended for implementation. However, if the boiler replacement project (B4) is implemented, this project will no longer be economically justified.

Σ

Project B3 — Automatic Blowdown with Heat Recovery: Installation of continuous blow-down controls, coupled with small shell and tube heat exchangers to heat makeup water, will save heating energy lost for surface blowdown. Manual blowdown of the boilers at Building 506 is carefully controlled; therefore, only minimal energy savings would be realized from automatic blowdown. Most of the cost savings is generated by reduced operations and maintenance requirements.

The life cycle cost analysis of this project yields a positive recommendation. However, if the boiler replacement project (B4) is implemented, this project would no longer be applicable.

Project B4 — New Boilers Sized for Present Demand: The existing boilers, each with a capacity of 4,315 pounds per hour of steam, were originally sized for dining facility loads (cooking and dish washing) in addition to space heating and domestic hot water (DHW) heating loads. The lack of use of the dining facility, and conversion of the dormitory space to offices for part of the building, has resulted in a reduced heating load. In addition, savings in heating load result from the recent installation of exterior wall insulation. Therefore, the existing boilers are oversized for their present demand and cycle frequently, wasting fuel.

Installation of smaller modular boilers sized for present loads will reduce losses from boiler cycling and provide heating at efficiencies only available with state-of-the-art modular boilers. Two options are evaluated: a modular heating plant sized for the total present demand load for both space and DHW heating (B4A) and a modular heating plant sized for DHW heating loads only (B4B). The modular hot water (HW) boilers will provide heating hot water and domestic hot water, as applicable, downstream of existing steam-to-hot water heat exchangers. Both options are developed assuming existing boilers remain in place and are available for reactivation in the event the dining facility is reopened.

Life cycle cost analyses of option B4A, heating and DHW services yields positive results. Option B4B, providing modular boilers only to serve DHW loads, provides less efficient heating service because the existing steam boilers would be used for space heating; the SIR is below 1.0.

Boiler Tune-Up (BTU) projects have been implemented in many Army installations and have proven beneficial in saving boiler fuels. The frequent trimming of burner controls associated with these programs is the principal mechanism for energy savings. The BTU program, however, is not applicable to the boilers serving Building 506, as they are attended a minimum of three hours per day, five days per week. The operator already frequently trims up the boiler burners.

Detailed calculations for boiler efficiency improvement projects are provided in Appendix C and boiler plant efficiency calculation methods are provided in Appendix D.

4.4.2 Cooling Equipment

Energy savings opportunities evaluated for cooling equipment included in the study:

- Chilled Water Temperature Reset
- Replacement of Glycol Chiller at Building 506
- Optimal Cooling Tower Control (Condenser Water Temperature Reset)
- Electronic Expansion Valve Retrofit for DX Units
- Duty Cycling Controls, Demand Limiting
- Shading Air Cooled Condensers
- Manifolding Chillers
- Evaporative Precooling

Detailed calculations for cooling equipment ECOs appear in Appendix F and explanations of these retrofit measures are provided in the following paragraphs.

Chilled Water Temperature Reset: Chilled water temperature reset control represents significant energy savings. Resetting the temperature at which chilled water is supplied saves energy by chilling the water only to the temperature necessary to satisfy the load. For air conditioning applications, it is possible to index this load to the outdoor ambient temperature. It is assumed that building skin cooling load decreases with the ambient temperature.

The retrofit is modeled by decreasing the entering and leaving chilled water temperature differential (raising chilled water supply temperature) at every instance where the measured outdoor temperature is below a selected value. If, at this time the measured power input indicates that the chiller is on, the decreased electric demand of the chiller, when supplying higher temperature chilled water, can be calculated and subtracted from loads measured during normal temperature chilled water supply operations. This demand savings is extended to a yearly kWH cost savings and compared with the investment required to install a temperature reset control package. Several chillers are recommended for this retrofit.

Replace Glycol Chiller at Building 506: The chiller used to cool ethylene glycol for the Ice-On-Coil system serving Building 506 was converted from a water chiller in order to reduce construction costs of the thermal storage system. As a consequence, the 80 ton water chiller was derated to about 45 tons for its new purpose.

Replacing this chiller with one designed for service to generate ice was considered. Calculations shown in Appendix F result in an SIR of 1.20 and a payback period of about 9.4 years. Although it is recommended that the chiller be replaced, consideration should be given to delaying its replacement, due to the 9+ year payback, until the unit fails.

<u>Optimal Cooling Tower Control (Condensate Water Reset)</u>: Optimal cooling tower control is another form of temperature reset, but in this case, the condenser water temperatures controlled only to that necessary to satisfy the condenser load. Cooling tower fan speed is reduced, which allows the condenser water temperature to rise. Fan speed is adjusted to the lowest speed (highest condenser water temperature) that will satisfy the load. The process utilizes a control package which varies the speed of the tower fan in response to cooling load, chiller or compressor output and condenser water temperature. This strategy is best suited for cooling systems consisting of one larger condenser and one cooling tower (or group of towers) with variable speed fans, all utilizing a direct digital control package. Since this control configuration was not found in any of the buildings studied, a detailed description of the model is provided to only a few of the chillers studied. Implementation of this measure is <u>not</u> recommended for the chillers evaluated.

<u>Electronic Expansion Valve Retrofit for DX Units</u>: Electronic expansion valves are considered for the direct expansion (DX) units in Buildings 3482 and 3510. Energy savings are achieved by reducing the refrigerant system pressure to only that necessary to complete the cycle. This is done by varying the expansion valve orifice in response to the super heat of the refrigerant gas leaving the evaporator. The basic function is to keep the evaporator active without permitting unevaporated refrigerant liquid to be returned through the suction line to the compressor. By keeping the system operating pressure to a minimum, compressor energy is conserved.

DX units in Buildings 3482 and 3510 are fitted with thermostatic expansion valves. Replacing valves in these two units and installing direct digital controls (DDC) would be prohibitively expensive for only two installations. Such a system of control is normally integrated with an EMCS system.

<u>Duty Cycling Controls</u>: Installing programmable controllers to turn off chillers 10 minutes per hour during peak electrical demand periods is considered for chillers serving only Buildings 451 and 3490. Building 506 already has a load shedding system, the ice-on-coil system. Buildings 2105, 3482 and 3510 serve critical mission functions and/or house explosives; thus, electrical loads may not be shed. Load shedding at Buildings 451 and 3490 will limit electrical demand, saving penalty charges by the Western Area Power Authority (WAPA). Yuma Proving Ground is charged $1.98 per kW-Month. This is a very low demand charge compared to commercially available power supplies elsewhere, however,

a penalty of 10 times this rate is charged whenever power demand exceeds YPG's allocation. The allocation is rarely exceeded and never more than once annually. Energy cost savings, thus, assume one excursion per year.

This retrofit is recommended for installation to allow future connection to a basewide EMCS; all chillers not servicing critical mission requirements should be connected to such a load shedding system.

Shading Air Cooled Condensers: Shading of the air cooled condensers is considered for Building 451, the glycol chiller at Building 506 and three chillers at Building 3490. Shading reduces the solar heat gain experienced by the condensers, thus, their temperatures. Condensing temperature is held closer to the outdoor air temperature and chiller performance is retained. All the chillers addressed in this survey are located on their building's North sides, with the single exception of the smallest chiller (C-1) serving building 3490. This is the smallest chiller evaluated; energy savings potential does not justify installation costs.

Manifold Chillers: Manifolding chillers is an option that increases the part loading capability of a system utilizing multiple chillers serving a buildings or loads in close proximity. By connecting the chillers in parallel to common chilled water supply and return headers, the part loading capability of the system as a whole can be increased to the sum of the part loading capabilities of each chiller. The only applicable case for this option is Building 3490. Manifolding of chillers C-2 and C-3 is recommended for implementation.

Evaporative Precooling of Air Cooled Chiller Condenser Cooling Air: The possibility of installing indirect evaporative precoolers on air cooled chiller condenser air inlets at Building 451 was investigated as a test case. Energy savings are achieved by providing lower temperature air to the condenser coils. This effectively increases both cooling capacity and the energy efficiency ratio. Indirect evaporative coolers are selected rather than direct evaporative coolers in order to avoid scaling and maintenance problems that could arise with the use of direct application of water to the coils.

Although significant energy savings can be achieved, the required investment exceeds the life cycle energy cost savings. Thus, this energy conservation measure is not recommended. If, however, it is necessary to extend the capacity of a chiller, due to increased loading for example, this retrofit can increase capacity by about 15 to 20 percent at the height of the summer.

4.4.3 Lighting Retrofits

Energy saving retrofits evaluated for the study buildings include lighting fixture modifications, lighting fixture replacements and installation of lighting controls.

Fixture modifications evaluated include (a) one-for-one standard ballast and 40 watt, T12 fluorescent lamp replacement with electronic ballasts and 32 watt, T8 lamps and (b) retrofit of 4-lamp fixtures with 3-lamp electronic ballasts, 32 watt, T8 lamps, and specular reflectors to maintain existing illumination levels.

Lighting fixture replacements evaluated include (a) two F32/T8 lamps and electronic ballast fixtures to replace existing ceiling mounted incandescent fixtures with three or four 60 watt lamps, and (b) two F20/T8 lamps and electronic ballast fixtures to replace existing wall mounted incandescent fixtures above lavatories in bathrooms.

Lighting control retrofits evaluated involve installing occupancy sensor switching in offices, conference rooms, bathrooms and other areas where lights are normally left on for periods when no one is present. Two types of occupancy sensors were considered. A wall switch type sensor is the least expensive and simply replaces a small office's toggle switch. For larger offices and open areas, ceiling mounted sensors were evaluated. Ceiling mounted switches are more expensive, as a relay and additional wiring are required.

Energy savings of at least 25% has been achieved in many similar retrofits according to Arizona Public Service Company. This savings level is assumed for these evaluations. This figure may be low for many offices observed during field investigations conducted for the study. In Building 2105, for example, many offices and office areas were observed to be unoccupied at least 50% of the time. Manufacturers of occupancy sensor switches report savings between 35% and 75% depending on room usage.

Results of evaluations are summarized on Table 4-1; details are provided on Table 4-2 for recommended ECOs and on Table 4-3 for unsuccessful ECOs.

4.5 Recommended Energy Conservation Projects

A summary of all ECO evaluations is provided in Table 4-1. A summary of results for ECOs recommended is provided in Table 4-2 and for ECOs not recommended in Table 4-3.

Overall, savings from the recommended ECOs include about 973,000 kWH per year (3,321 MBTU per year) of electric power savings, 578 million BTUs per year of LPG fuel savings and 466 million BTUs per year of No. 2 Fuel Oil savings. About $27,580 per year is saved in operation and maintenance expenses. The total life cycle cost savings amounts to about $1.35 million and is realized by an investment of about $632,300. The combined savings-to-investment ratio is 2.14, the payback period is 5.3 years.

Table 4-1
Summary of ECO Evaluations

No.	Description of ECO	SIR Greater Than 1.0	SIR Less Than 1.0	Recommended Project
	Building 506 Boiler Efficiency Improvements			
B1	High Efficiency Burners and O_2 Trim Controls	✓		
B2	Install Engineered Turbulators in Fire Tubes	✓		
B3	Automatic Boiler Blowdown with Heat Recovery	✓		
B4A	New Modular Boilers for Heating and Domestic Water	✓		✓
B4B	New Modular Boilers for Domestic Water Only		✓	
	Cooling Equipment ECOs			
	Chilled Water Temperature Reset (Buildings 506, C-1, 2105 C-1 and C-5)	✓		✓
	Chilled Water Temperature Reset (Buildings 451, 2105 C-2, 3490 C-1, C-2 and C-3)		✓	
	Replace Glycol Chiller at Building 506	✓		✓
	Electronic Expansion Valves (Buildings 3482 and 3510)		✓	
	Optimize Cooling Tower Control (Condenser Water Temperature)		✓	
	Manifold Chillers C-1, C-2 and C-3 at Building 3490	✓		✓
	Duty Cycling Controls, Demand Limiting	✓		✓
	Shading Air Cooled Condensers		✓	
	Evaporative Precooling		✓	
	Lighting and Control ECOs			
A	Retrofit: 1-Lamp Electronic Ballast and T8 Lamp	✓		Most
B	Retrofit: 2-Lamp Electronic Ballast and T8 Lamps	✓		✓
C	Retrofit: 3-Lamp Electronic Ballast and T8 Lamps	✓		✓
D	Retrofit: 4-Lamp Electronic Ballast and T8 Lamps	✓		Most
E	New Fixture: 1-Lamp Electronic Ballast and T8 Lamp		✓	
F	New Fixture: 2-Lamp Electronic Ballast and T8 Lamps	✓		Most
G	New Fixture: 3-Lamp Electronic Ballast and T8 Lamps — Explosion Proof		✓	
H	Retrofit: 3-Lamp Electronic Ballast and T8 Lamps and Specular Reflector	✓		✓
I	Retrofit: Occupancy Sensor Lighting Control — Ceiling Mounted	✓		✓
J	Retrofit: Occupancy Sensor Lighting Control — Auto. Wall Switch	✓		✓
K	New Fixture: 2-Lamp Compact Fluorescent, 2 x 13W/5T4	✓		✓
L	New Fixture: 2-Lamp Electronic Ballast and T8 Lamps, 2' Surface Mount	✓		✓
M	Install Switching for Assembly Rooms — Building 3482	✓		✓

Notes:
Only one Boiler Efficiency project group may be implemented: (B1, B2 and B3), B4A or B4B. B4A is recommended.
Lighting and control ECOs where recommendations are shown as "Most" are evaluated separately for each building; buildings in which the ECOs show SIRs > 1 are recommended.

Table 4-2
Recommended Energy Conservation Opportunities

Project Number	Description	Electric Savings kW	Electric Savings kWH/Yr	Fuel MBTU/Yr Distillate	Fuel MBTU/Yr LPG	Energy Cost Saved $/Year	Energy Cost Saved LCC $	O&M Cost Saved $/Year	O&M Cost Saved LCC $	Investment $	Economic Measures SIR	Economic Measures Payback	Economic Measures AIRR
Recommended Building 506 Boiler Efficiency Improvement Projects													
B1	New Burners & O2 Trim	-	-	330	346	$6,923	$87,045	($1,320)	($14,177)	$62,241	1.17	11.1	5.6%
B2	Engineered Turbulators	-	-	164	163	$3,371	$42,346	($519)	($5,574)	$2,186	16.8	0.8	26.1%
B3	Auto-Blowdown w/ Heat Recovery	-	-	3	2	$49.61	$622	$6,798	$73,011	$16,302	4.27	2.4	15.6%
Totals for B1, B2 & B3		-	-	497	511	$10,344	$130,013	$4,959	$53,260	$80,728	2.27	5.28	10.4%
B4A	Modular Boilers for Heating & DHW	-	-	466	578	$10,435	$131,662	$17,820	$191,387	$122,560	2.64	4.3	11.5%
B4B	Modular Boilers for DHW Only	-	-	200	247	$4,467	$56,354	($1,980)	($21,265)	$73,923	0.47	29.7	-0.6%

Note: Boilers in building 506 are dual fueled, alternating between No. 2 Fuel Oil (Distillate) and LPG; boilers serve building 506 only.

Recommendation:
Implement B4A - Each of the above project groupings are mutually exclusive, e.g., project B4A cannot be economically justified if the group of B1, B2 & B3 are implemented.

Project Number	Description	Electric Savings kW	Electric Savings kWH/Yr	Fuel MBTU/Yr Distillate	Fuel MBTU/Yr LPG	Energy Cost Saved $/Year	Energy Cost Saved LCC $	O&M Cost Saved $/Year	O&M Cost Saved LCC $	Investment $	Economic Measures SIR	Economic Measures Payback	Economic Measures AIRR
Recommended Cooling Equipment Energy Conservation Opportunities Evaluated													
	Chilled Water Temperature Reset (506 C-1, 2105 C-1 & C-5)	-	146,584	-	-	$12,166	$137,481	($1,584)	($17,012)	$30,304	3.98	2.86	14.6%
	Replace Glycol Chiller 506 C-2	-	80,000	-	-	$6,640	$75,032	-	-	$62,606	1.20	9.43	5.8%
	Manifold Chillers C-2 & C-3 at Building 3490	-	92,825	-	-	$7,704	$87,060	($1,320)	($14,177)	$57,321	1.27	8.98	6.2%
	Duty Cycling Controls	36.8	-	-	-	$1,164	$13,157	($132)	($1,418)	$6,524	1.80	6.32	8.7%
Total of Recommended Cooling Equipment ECOs		36.8	319,409	-	-	$27,675	$312,730	($3,036)	($32,606)	$156,755	1.79	6.36	8.6%
Recommended Lighting & Control Energy Conservation Opportunities Evaluated													
A	1-Lamp Electronic Ballast & T8 Lamp (2105S1 & 506A)	2.0	13,893	-	-	$1,153	$13,031	($104)	($1,115)	$7,885	1.51	7.51	7.4%
B	2-Lamp Electronic Ballast & T8 Lamps	50.3	213,214	-	-	$17,697	$199,973	($1,590)	($17,073)	$119,000	1.54	7.39	7.5%
C	3-Lamp Electronic Ballast & T8 Lamps	18.2	72,093	-	-	$5,984	$67,616	($602)	($6,463)	$36,991	1.65	6.87	8.1%
D	4-Lamp Electronic Ballast & T8 Lamps (506A & C)	2.3	7,868	-	-	$653	$7,379	($72)	($770)	$5,398	1.22	9.29	5.9%
F	2-Lamp Electronic Ballast & T8 Lamps (506B)	10.5	35,226	-	-	$2,924	$33,039	$6,132	$65,854	$32,560	3.04	3.60	12.5%
H	3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector	20.9	75,626	-	-	$6,277	$70,930	($109)	($1,176)	$34,379	2.03	5.57	9.5%
I	Ceiling Mounted Sensor Switch (2105, 3490, 506)	-	76,063	-	-	$6,313	$71,340	$0	$0	$31,097	2.29	4.93	10.4%
J	Automatic Wall Sensor Switch (451, 3490, 2105)	-	61,408	-	-	$5,097	$57,594	$0	$0	$20,560	2.80	4.04	11.9%
K	2-Lamp Compact Fluorescent 2 x 13W/5T4	4.1	16,076	-	-	$1,334	$15,078	$1,003	$10,769	$13,573	1.90	5.81	9.1%
L	2-Lamp Elect. Ballast & T8 Lamps, 2' Surface Mount	15.5	51,587	-	-	$4,282	$48,384	$8,138	$87,399	$36,279	3.74	2.92	14.1%
M	Install Light Switching for Assembly Rooms - Bldg 3482	-	30,680	-	-	$2,546	$28,775	$0	$0	$15,220	1.89	5.98	9.0%
Total of Recommended Lighting & Control ECOs		123.6	653,735	-	-	$54,260	$613,138	$12,796	$137,425	$352,942	2.13	5.27	9.9%
GRAND TOTAL OF RECOMMENDED ECOs		160.4	973,144	466	578	$92,370	$1,057,530	$27,580	$296,205	$632,257	2.14	5.27	9.9%

Includes Project B4A only from Boiler Efficiency Improvements

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Table 4-3
Energy Conservation Opportunities Not Recommended

Project Number	Description	Electric Savings kW	Electric Savings kWH/Yr	Energy Cost Saved $/Year	Energy Cost Saved LCC $	O&M Cost Saved $/Year	O&M Cost Saved LCC $	Investment $	SIR	Payback	AIRR
	Cooling Equipment Energy Conservation Opportunities Not Recommended										
	Chilled Water Temperature Reset (451, 2105 C-2, 3490)	-	8,225	$683	$7,712	-	-	$50,505	0.15	73.98	-7.81%
	Optimize Cooling Tower Control (Condenser Water Temperature Reset)	Project not recommended because none of the chilled water systems evaluated is large enough.									
	Shade Air Cooled Condensers from Sunlight	Project not recommended: all but 1 A/C chiller are located on the North sides of their buildings.									
	Evaporative Precooling of Air Cooled Condenser Air	Project not recommended because life cycle energy cost savings are less than the investment.									
	Lighting & Control Energy Conservation Opportunities Not Recommended										
A	1-Lamp Electronic Ballast & T8 Lamp (2105N,S2 & 3490)	0.90	3,567	$296	$3,345	($31)	($334)	$4,284	0.70	16.17	2.07%
E	New Fixture for Lighting ECO A (451,506, 2105 & 3490)	2.74	10,806	$897	$10,135	($80)	($863)	$46,326	0.20	56.74	-6.13%
D	4-Lamp Electronic Ballast & T8 Lamps (2105S2 & 506B)	1.11	3,075	$255	$2,884	($101)	($1,083)	$2,976	0.61	19.27	1.06%
F	2-Lamp Electronic Ballast & T8 Lamps (451)	0.30	1,099	$91	$1,031	$170.6	$1,832	$3,706	0.77	14.15	2.72%
G	3-Lamp Elect. Bal. & T8 Lamps - Explosion Proof (3482 & 3510)	28.91	64,242	$5,332	$60,253	$2,155	$23,140	$632,295	0.13	84.46	-8.70%
I	Ceiling Mounted Sensor Switch (506A)	0.00	3,847	$319	$3,608	$0	$0	$7,323	0.49	22.94	-0.32%
J	Automatic Wall Sensor Switch (506A & B)	0.00	19,999	$1,660	$18,758	$0	$0	$40,890	0.46	24.63	-0.79%

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5.0 Conversion to Non-Chlorofluorocarbon Refrigerants

5.1 Introduction

The Clean Air Act (CAA) which went into effect on July 1, 1992 states in Section 608, "It shall be unlawful for any person in the course of maintaining, servicing, repairing or disposing of an appliance or industrial process refrigeration, to knowingly vent or otherwise knowingly release or dispose of any Class I or Class II substance used as a refrigerant in such appliance (or industrial process refrigeration) in a manner which permits such substance to enter the environment." The purpose of this Act is to eliminate the refrigerants with the most global warming potential (GWP) and to protect the stratospheric ozone layer.

A violation of this section of the CAA carries a penalty of $25,000 per day and it is possible that the Environmental Protection Agency (EPA) may offer bounties for information on violators.

The existing chlorofluororocarbons (CFC) that are the most common refrigerants are CFC-11 and 12 and also CFC-113, 114 and 500 (which contains CFC-12). There is no "quick-fix" for the environment and there is no "instant replacement refrigerant" available at the present time that will solve all problems, be environmentally safe and still be cost effective. There will be an end to production of CFC's by 1996 and the transition of replacement refrigerants into existing equipment must be planned and implemented today.

There have been successful refrigerant replacement projects using Halocarbon refrigerants HCFC-123 in place of CFC-11 and HFC-134a in place of CFC-12. These newer refrigerants use polyester oil for lubrication.

The HCFC-123 refrigerant has 98% less ozone-depletion potential, less global warming impact and shorter atmospheric lifetime than CFC-11. Successful conversions reuse existing chiller equipment with changes in gaskets, seals and transducers. In addition, new purge vent lines are necessary and upgraded installation HCFC alarms and sensors are provided. The CFC-11 refrigerant is recovered from the equipment prior to the refurbishment and a new supply of HCFC-123 is charged into the unit and tested for leaks. Refrigerant recovery equipment for use by maintenance staff is available for purchase or rent. Alternatively, there are recovery contractors that can be hired. The life expectancy of existing equipment will not exceed the availability of HCFC-123 which will be produced until the year 2030. The newest alternate (HFC) refrigerant R-245ca is in the preliminary testing phases at the present time, but the results of preliminary comparisons between thermophysical properties and performance are very close to CFC-11 and HCFC-123.

The HFC-134a refrigerant has a zero ozone-depletion potential (ODP) and is presently being used in newly manufactured chillers. The use of either HCFC-123 or HFC-134a as a replacement refrigerant requires recalculation of equipment cooling capacity due to its lower theoretical efficiency; fans requiring derating of existing equipment. A reduction in chiller capacity of 10 to 25 percent will seriously affect the comfort level or process load of the application. The choice

of installed equipment does not usually allow for that large an oversizing in capacity, and the lower equipment efficiency will require 4% to 10% additional energy to be used.

The manufacturing of HFC-134a is a two-step process which means the cost of production is higher, thus making it the most expensive HCFC.

HCFC-22 at 5% ODP and HCFC-123 at 2% ODP are also scheduled for future phaseout and HFC-134a is presently the only refrigerant alternative available. A short term solution presently available for replacement of HCFC-502 is using HCFC-22 with the eventual replacement being HFC-134a, or future refrigerant blends which are under development.

Production phase out of CFCs and HCFCs required by the Montreal Protocol and subsequent amendments is summarized on Table 5-1. Short-term and long-term refrigerant solutions for various system types are summarized on Table 5-2.

Table 5-1
Refrigerant Production Table
(Montreal Protocol Production Caps)

CFCs	**1 January**	
	1993	50% of 1986 production level
	1994	25%
	1995	25%
	1996	0%
HCFCs	Production caps begin January 1 1996, based on 3.1% of CFCs used in 1989 *weighted by ozone depletion potential* (ODP); **plus** ODP-weighted 1989 HCFC consumption... Thus:	
	1 January	
	1996	Cap (Above formula)
	2004	65% of cap
	2010	35% of cap
	2015	10% of cap
	2020	0.5% of cap
	2030	0.0% — Total Phaseout
HFCs	Not regulated by Montreal Protocol	

Σ

Table 5-2
Short-Term and Long-Term Refrigerant Solutions

System Type	Refrigerant Existing	Short-Term Solution	Long-Term Solution
Chillers	CFC-11(1),113	HCFC-123	HCFC-123(2)
	CFC-12, R-500	HFC-134a	HFC-134a
	CFC-114	HCFC-124	HCFC-124
	HCFC-22(2)	HCFC-22(2)	HFC-134a
Refrigerators/Freezers	CFC-12	HFC-134a	HFC-134a
Mobile Air Conditioners	CFC-12	HFC-134a	HFC-134a
Transport Refrigeration	CFC-12	HFC-134a	HFC-134a
Commercial Refrigeration			
— High and Medium Temperature	CFC-12(1)	HFC-134a	HFC-134a
— Low Temperature	HCFC-502(2)	HCFC-22(2)	HFC-134a
Industrial Refrigeration	CFC-502(1)	HFC-134a	HFC-134a
Residential Air Conditioning and Heat Pumps	HCFC-22(2)	HCFC-22(2)	HFC-134a

Notes:
1. After 1996, 0 production per Montreal Protocol Table 5-1.
2. After 2030, 0 production per Montreal Protocol Table 5-1, but by 2020 the production of .5% will make it very expensive to use and HFC-245ca is only in the preliminary test stage at the present time.

5.2 Yuma Proving Ground Chillers

The existing refrigeration equipment included in this survey uses CFC-11, CFC-113, HFC-134a and HCFC-22. There are three options available for dealing with the CFC issue:

- Existing refrigerant can be contained
- Equipment can be retrofitted for conversion to non-CFC refrigerants
- Equipment can be replaced with units built for an HFC refrigerant

5.2.1 Containment of Existing Refrigerants

The containment option insures that no refrigerant is lost to the atmosphere and therefore does not need replacement. In addition to careful maintenance, use of a recovery and recycle unit and

replacement of leaking purge units is required. Accurate operating logs are required to verify that the chillers are fully charged, including evaporator refrigerant approach temperatures. The recovery unit is used to remove and store all refrigerant prior to opening a unit for servicing. After servicing, a thorough leak test is performed and the system is completely evacuated using the recovery unit. A 24-hour standing vacuum test is conducted to verify unit integrity. This option might be considered as a short-term solution, especially for R-22 equipment, but it would normally be a poor long-term choice because if refrigerant is lost for any reason, there would be no replacement refrigerant available.

Yuma Proving Ground (YPG) is, however, in a unique position to obviate this future refrigerant supply problem. Large stocks of all refrigerants are retained by the Army on site. This supply, augmented by refrigerant collected from older chillers being taken out of service, could provide for long term requirements, or at least until other refrigerants are developed, tested and released for sale.

5.2.2 Conversion to an HFC Refrigerant

The second choice is that of conversion. This is a reasonable option for equipment of relatively large capacity (over 200 ton) and less than 10 years old. Due to different operating characteristics and corrosiveness of the new refrigerants, the following chiller analysis and retrofitting may need to be implemented: computer analysis for energy and capacity tradeoffs; metal integrity/structural analysis to evaluate effects of casing erosion/thinning; drive line changes (compressor, motor and speed gear); seals and electric motor changes; and economizer/orifice plate changes. The cost to implement some or all of these retrofits may sometimes outweigh that of an entirely new chiller.

5.2.3 Replace Chillers with an HFC Refrigerant Chiller

As the CFC phase-out date approaches, all major equipment manufacturers are introducing new lines of CFC free chillers. The Carrier Corporation makes a screw chiller using HCFC-22 available in capacities from 160 to 250 tons with efficiencies of 0.63 to 0.7 kW per ton, as well as centrifugal chillers using HFC-134a in capacities ranging from 800 to 1,300 tons and efficiencies from 0.6 to 0.64 kW per ton. York International manufactures centrifugal chillers from 100 to 850 tons using HCFC-22 and 260 to 2,100 tons using HFC-134a. Full load rating range from 0.6 to 0.7 kW per ton. In addition, the York water cooled screw chiller is available from 100 to 1,250 tons using HCFC-22 and 100 to 450 tons using HFC-134a with full load ratings from 0.6 to 0.7 kW per ton. Snydergeneral Corporation's McQuay centrifugal chillers range from 70 to 1,300 tons and use HFC-134a. The Trane Company offers a full line of HCFC-123 centrifugal chillers with efficiencies of 0.55 kW per ton.

5.2.4 Chiller Manufacturer Refrigerant Containment Programs

In addition to product options, there are several refrigerant management service options offered by various manufacturers.

- Carrier Corporation
  The program is designed to allow existing CFC-11 chillers to operate using their original refrigerant. The program applies to existing CFC-11 chillers made by any manufacturer and located anywhere in North America. Participants are required to equip their chillers with a PreVent high efficiency purge, a VaporSaver™ relief valve and alarm, and an OilSense™ oil quality monitor. The high efficiency purge reduces refrigerant losses by up to 99 percent during the normal purging cycles. The VaporSaver's metallic, non-fragmenting rupture disk relieves chiller pressure while the pressure relief valve re-seals the chiller once pressure is reduced to a safe level. The oil quality monitor signals when oil is approaching degradation or contamination. The monitor detects changes in oil condition due to water content, thermal breakdown, acidity levels or metal content. Participants in the program must also sign the company's ServicePlus agreement, which provides customized chiller maintenance and service. Sign-ups for the Chiller Operation Assurance program will cease at the end of 1994.

- York International
  A Chiller Conversion and Retrofit Services Group expedites conversion engineering and related services. Three options are offered for converting the company's open-drive CFC-11 chillers to HCFC-123. The first involves a change out of seals and gaskets, new refrigerant charge and an adjustment in controls to handle the new operating temperatures and pressures. Capacity usually drops in such a conversion. An engineered conversion retains full capacity. It includes a gear change to compensate for the different thermodynamics of the replacement refrigerant. The third option is a drive-line retrofit which can be performed on essentially any centrifugal chiller as long as the heat exchanger shells are in good working order. The chiller's old motor, compressor and controls are replaced with a new open-motor drive-line and DDC controls. The company provides a new chiller warranty with drive-line retrofits. Engineered conversions and drive-line retrofits are available to convert CFC-12 chillers to HFC-134a as well. The company also offers services in refrigerant management and conservation, including inspections of chiller systems; recommendations for leak reduction and improvements in chiller efficiency; evaluation of refrigerant handling, storage and transportation practices to ensure that they comply with applicable laws; and assistance in planning and implementing plans to reduce dependence on CFCs.

- Snydergeneral Corporation
  The company's service arm, McQuayService, has developed a program designed to help independent contractors with conversions of existing McQuay or Westinghouse centrifugal chillers to HFC-134a. The program is intended to assure that building owners can turn to properly trained independent contractors for conversions. In addition to providing start-up labor and other services, the program includes educational materials to help building owners and managers better understand the CFC issue. McQuayService also offers chiller conversions.

- Trane
  The company will survey its existing CFC-11 centrifugal chillers to help equipment owners determine whether to continue to operate at reduced emissions, convert to HCFC-123 or replace with new equipment. A system needs survey begins with an evaluation of the original system design, building shell enhancements and interior load changes, and functional changes in the chiller plant. The assessment also looks at existing utility rates and possible changes to these rates. A typical equipment conversion involves replacement motor, O-rings and gasketing materials throughout the chiller. Computer modeling is used to optimize compressor and flow devices (orifices) for maximum capacity. Additional applications could involve converting the chiller for thermal storage or other design criteria.

5.3 Recommendations for Yuma Proving Ground Chillers Surveyed

Data on existing chillers included in the study is summarized on Table 5-3. A summary of retrofit recommendations for the cooling systems included in the study is provided in Table 5-4. Case-by-case evaluations and cost estimates appear in Appendix F.

Continued use of existing chillers is probably the least expensive option available. However, in order to comply with the law, certain equipment retrofits will be required to assure that refrigerants are not released to the atmosphere.

Several chiller manufacturers, as addressed above, offer programs to contain CFC-11 refrigerants in existing systems. Costs of such programs include an initial expenditure of about $12,500 to install a purge unit and reseatable relief valve.

For an additional amount of around $4,000 per year, chiller manufactures will conduct annual service and will provide periodic checks. Oil analyses are performed and the oil is changed as needed. Several manufacturers will also provide a guarantee, at an additional cost of about $1,000 per year. The guarantee assures the chiller owner of continued refrigerant supplies throughout the life of the chiller. Most such programs require enrollment before the end of calendar year 1994.

Replacement chillers using HFC-134a, the only HFC currently available, are sized from about 200 tons capacity and higher. Smaller capacity chillers using HFC refrigerants are not yet widely available. Most of the chillers in this study fall into this smaller category. Replacing a chiller because its refrigerant is no longer manufactured is not cost effective if refrigerant for maintenance is available.

Changes in the law only stop the manufacture of CFC's in 1996 and HCFC's by 2030. Maintenance will always require some replacement refrigerant. However, smaller installations without many buildings will probably not have refrigerant available from units being removed from service. YPG has numerous facilities. Refrigeration devices are being added, repaired and/or replaced continuously. The Army keeps a stock of refrigerant on hand to accommodate maintenance practices. It is recommended that all refrigerants removed from units being maintained and/or removed from service be retained by the Army for future needs; a contract may be required to

"recondition" the refrigerants. The practice of keeping such refrigerants on hand will assist in extending the useful life-times of newer units not yet ready for conversion or replacement.

The recommendations shown on Table 5-4 are based on the assumption that HFC refrigerants will become available for smaller chillers before the existing chillers reach the ends of their lifetimes.

Thus, the first choice is to "contain" refrigerants for all devices. The next choice is to convert chillers to HFC type refrigerants, if it can be done cost effectively. The last choice is complete chiller replacement.

It may be necessary to convert some machines, paying the capacity penalty of between 10% and 20%. Energy conservation opportunities evaluated in this study may assist in compensating for this capacity penalty. Lighting retrofit projects recommended in this study reduce electric loads seen by the air conditioning systems. Cooling load reductions from lighting retrofit projects are estimated as follows:

- Building 451: 5.0 kW = 1.4 Tons reduction
- Building 506: 44.4 kW = 12.6 Tons reduction
- Building 2105: 63.9 kW = 18.2 Tons reduction
- Building 3482: 0 kW (no credit taken for switching) = No reduction
- Building 3490: 10.3 kW = 2.9 Tons reduction
- Building 3510: 0 kW = No Tons

Evaluation of the glycol chiller used on the Building 506 ice-on-coil storage system indicates it would be cost effective to replace it with a higher efficiency glycol chiller. The existing chiller was originally installed as a chilled water chiller for space-cooling purposes. It was converted to a low-temperature glycol chiller and derated from 80 tons to 45 tons capacity.

Table 5-3
Summary of Existing Chiller Data

Building Number	Unit Description	Capacity (Tons)	Manufacturer	Refrigerant	Built (Year)
451	A/C Reciprocating	55	Carrier	HCFC-22, 136 lbs.	1987
506	W/C Centrifugal	220	Trane	CFC-11, 450 lbs.	1974
506	A/C Reciprocating — Glycol(1)	45	Trane	HCFC-22 (Rebuilt)	1988
2105	C-1 W/C Centrifugal	125	Trane	CFC-113, 415 lbs.	1977
2105	C-2 W/C Reciprocating	40	Trane	HCFC-22, 55 lbs.	1977
2105	C-5 W/C Centrifugal	125	Carrier	CFC-11	1984
3482	W/C Reciprocating — DX	62	Carrier	HCFC-22	1970
3490	C-1 A/C Reciprocating	25	Webster	HCFC-22	1987
3490	C-2 A/C Reciprocating	50	Webster	HCFC-22	1987
3490	C-3 A/C Reciprocating	100	Webster	HCFC-22	1987
3510	W/C Reciprocating — DX	40	Trane	HFC-134a(2)	1993

A/C: Air-Cooled W/C: Water-Cooled DX: Direct Expansion Unit

Notes:
1. The 45-ton glycol chiller installed at Building 506 serves the ice-on-coil system and was retrofitted from a water chiller, previously rated at 80 Tons.
2. The compressor serving the Building 3510 cooling system was rebuilt in 1993. System is presently in good condition. Conversion to HFC-134a included refrigerant only; seals were not replaced.

Table 5-4
Recommendations for Study Chillers

Bldg. No.	Unit Description	Age in 1994	Age in 2020	Options (order of choices)			Recommendations for Action
				Contain	Convert	Replace	
451	A/C Reciprocating	7	33	1	3,2	2,3	Contain; replace ca. 2012
506	W/C Centrifugal	20	46	2	3	1	Replace
506	A/C Reciprocating — Glycol	6	32	1	3,2	2,3	Replace now (see Note 1)
2105	C-1 W/C Centrifugal	17	43	2	3	1	Replace
2105	C-2 W/C Reciprocating	17	43	2	3	1	Replace
2105	C-5 W/C Centrifugal	10	36	1	3	2	Contain; replace ca. 2009
3482	W/C Reciprocating — DX	24	50	2	3	1	Replace now
3490	C-1 A/C Reciprocating	7	33	1	3,2	2,3	Contain; replace ca. 2012
3490	C-2 A/C Reciprocating	7	33	1	3,2	2,3	Contain; replace ca. 2012
3490	C-3 A/C Reciprocating	7	33	1	3,2	2,3	Contain; replace ca. 2012
3510	W/C Reciprocating — DX	1	27	1	N/A	N/A	Contain; retain as-is

A/C: Air-Cooled
W/C: Water Cooled
ca.: circa (about)
DX: Direct Expansion Unit

Notes:
1. Replacing with a higher-efficiency unit is cost-effective and, thus, recommended as an energy conservation measure (refer to Appendix F for calculations).
2. Carrier Corporation makes the following recommendations based on chiller age:
   Chiller < 7 Years old: 1 = Contain, 2 = Replace/Convert, 3 = Replace
   Chiller 7-15 Years old: 1 = Contain, 2 = Replace, 3 = Convert
   Chiller > 15 Years old: 1 = Replace, 2 = Contain, 3 = Convert

6.0 Energy Monitoring and Control System Evaluation

6.1 Existing System

Yuma Proving Ground (YPG) has been fitted with an FM-based Energy Monitoring and Control System (EMCS) for many years. The existing system receives signals from two power substations, monitoring electrical demand. Signals are presently transmitted to five or six chiller systems for load shedding whenever the demand approaches load limits from either Arizona Public Service Company or the Western Area Power Authority (WAPA). Significant cost penalties are incurred if YPG exceeds their allocated electrical demand from either source.

The system is a composite of Motorola Exoterm 155 systems and other components from various sources. The existing system is obsolete; replacement parts are only available for a few of the components. It is only operating, at this time, due to the ingenuity of YPG Directorate of Public Works personnel.

Over the years, most of the numerous receiver/transmitters connected to systems to facilitate load shedding have been disconnected.

Future expansion of the EMCS using existing spare components maintained at YPG is not recommended because of their obsolescence.

6.2 Energy Monitoring and Control System Evaluation

The analysis of a new EMCS and its impact on chiller and boiler operation and energy savings only takes into account costs and savings for chiller and boiler plant applications independent of other equipment that would likely be incorporated into the EMCS (lighting, etc.). The option was found not to be favorable, when considering only the six buildings included in this study, with a simple payback period of 18.9 years, a savings-to-investment ratio (SIR) of 0.61 and an adjusted internal rate of return of only 1.10%.

If a new EMCS were extended to all significant energy-using buildings, including 290 units of family housing, project economics would likely improve significantly. Low-cost receive-only FM-radio devices could be installed at each family housing unit to deenergize air conditioning loads during peak demand periods. It is recommended that a basewide EMCS be investigated.

Cost estimates take into account equipment and wiring for each point to be monitored or controlled, analog and digital input and output modules, associated remote terminal units and software packages, central supervisory control center equipment and software, and FM-radio data transmission system. Detailed cost estimates are included in Appendix I.

Energy savings from cooling systems was obtained by totalling savings associated with direct digital control (DDC) applications for chiller selection, chilled water reset, condenser water reset and chiller demand limiting. Detailed calculations appear in Appendix F.

Energy and operation and maintenance savings estimates from installation of EMCS controls on boiler plants are based on reduced labor requirements and on boiler efficiency improvements achieved by hot water temperature reset controls. Calculations appear in Appendix I.

Input/output summary tables with listings of all points to be monitored or controlled and applicable software packages for each building are included in Appendix I. A description of each DDC application follows. Expected energy savings are summarized on Table 6-1.

6.3 Description of Potential EMCS

6.3.1 Data Transmission Medium

Due to the widely-geographically-dispersed layout of YPG facilities (Buildings 3482, 3490 and 3510 are located over 15 miles from the Main Administrative Area), use of a physically-connected data transmission system such as fiber optics or dedicated wire lines was rejected. The exorbitant cost of such long runs of data transmission media would push even the most beneficial retrofit into red ink. Accordingly, a two-way FM-radio system connecting the central supervisory control center to the remote units is the proposed data transmission system. A repeater, duplexer, and tower antenna would be needed to allow line-of-sight communications across the hilly terrain east of the Main Administrative Area. The remote transceivers could be an integral component of the remote terminal units.

6.3.2 Central Supervisory Control Center

The central supervisory control center would consist of a standard personal computer (486 or Pentium microprocessor-based), alarm printer, and logging printer. The computer's serial communications port would interface with a modem and head-end transceiver. A tower would be provided for the head-end antenna to assure two-way radio coverage of all built-up areas in Yuma Proving Ground from the DEH compound in the Main Administrative Area.

6.3.3 DDC Applications Programs

6.3.3.1 Chiller Selection

The chiller selection program is implemented in chilled water plants with multiple chillers. Based on chiller operating data and the energy input requirements obtained from the manufacturer for each chiller, the program will select the chiller or chillers required to meet the load with the minimum energy consumption. When the chiller or chillers are started, chiller capacity must be limited (prevented from going to full load) for a predetermined period to allow the system to stabilize in order to determine the actual cooling load. Comparison of equipment characteristics versus the actual operating chiller characteristics make it possible to determine when heat transfer surfaces need cleaning to maintain the highest efficiency. The program must follow the manufacturer's start up and shut down sequence requirements. Interlocks between chilled water pumps, condenser water pumps, and chiller must be in accordance with the chiller manufacturers requirements. Chillers

may be started automatically by the EMCS or manually by the chiller operator depending on operating requirements.

6.3.3.2 Chilled Water Temperature Reset

The energy required to produce chilled water in a reciprocating or centrifugal refrigeration machine is a function of the chilled water supply temperature. The refrigerant suction temperature is also a direct function of the supply water temperature; the higher the suction temperature, the lower the energy input per ton of refrigeration. Chilled water supply temperature is selected for peak design times; therefore, the supply temperature can be reset upward during non-peak operating hours to the maximum which will still satisfy space cooling requirements. The program resets chilled water temperature upward until the required space temperature or humidity set points can no longer be maintained. This determination is made by monitoring positions of the chilled water valves on various cooling systems or by monitoring space temperatures.

6.3.3.3 Condenser Water Temperature Reset

The energy required to operate refrigeration systems is directly related to the temperature of the condenser water entering the machine. Heat rejection systems are designed to produce a specified condenser water temperature such as 85°F at peak wet bulb temperatures. Automatic controls are provided at some sites to maintain a specified temperature at conditions other then peak wet bulb temperatures. In order to optimize the performance of refrigeration systems, condenser water temperature is reset downward when outdoor air wet bulb temperatures will produce lower condenser water temperature. The reset schedule will incorporate the manufacturer's requirements governing acceptable condenser water temperature range.

6.3.3.4 Chiller Demand Limit

Centrifugal water chillers are normally factory equipped with an adjustable control system which limits the maximum available cooling capacity and, therefore, maximum power demand. An interface between the remote terminal unit and the chiller controls allows the EMCS to reduce the maximum available cooling capacity in several fixed steps in a demand limiting situation, thereby reducing the electrical demand without completely shutting down the chiller. The method of accomplishing this function varies with the manufacturer of the chiller. The chiller percent capacity is obtained by monitoring the chiller current input. When the chiller is selected for demand limiting, a single step signal is transmitted, reducing the chiller limit adjustment by a fixed amount. The chiller demand limit adjustment is performed by shunting out taps of transformers in the control circuit or by resetting the control air pressure to the chiller compressor vane operator. As further need arises, additional stop signals are transmitted until the demand limiting situation is corrected. Extreme caution should be exercised when applying this program, since incorrect control can cause the refrigeration machine to operate in a surge condition, potentially causing it considerable damage. The chiller manufacturer's recommended minimum cooling capacity limit will be incorporated into the sequence of operation. In general, surges occurs in chillers at loads below 20% of the rated capacity.

6.3.3.5 Remote Boiler Monitoring

The benefits of adding an EMCS to boiler systems is primarily in safety and more efficient system operation. The EMCS is able to improve response time to system problems by detecting alarm conditions in the system without requiring an operator to manually inspect each system. The EMCS saves energy costs by avoiding simultaneous heating and cooling, and operation and maintenance labor by eliminating some of the periodic personal inspections.

6.3.3.6 Steam Boiler Selection

The Steam boiler selection program is designed to select the most efficient boiler in a multiple boiler plant to satisfy the heating load. Boiler operating data will be obtained from the manufacturer, or developed by monitoring fuel input as a function of the steam output. Determination of boiler efficiency also takes into account the heat content of the condensate return and make-up water. Based on the efficiency curves, fuel input versus steam output, the boilers with the highest efficiency can be selected to satisfy the heating load. Boilers may be started manually by a boiler operator or automatically by EMCS, depending on site requirements. Burner operating efficiency is monitored by measuring the O_2 or CO and flue gas temperature in each boiler flue.

6.3.3.7 Hot Water Boiler Selection

Hot water boiler selection is implemented in heating plants with multiple boilers. The techniques and considerations are the same as discussed above.

6.3.3.8 Hot Water Boiler Outside Air Temperature Reset

Hot water heating systems, whether the hot water is supplied by a boiler or a converter, are designed to supply hot water at a fixed temperature. Depending on the system design, the hot water supply temperature may be reduced as the heating requirements for the facility decrease. A reduction in hot water supply temperature results in reduction of heat loss from equipment and piping. To implement this program, the temperature controller for the hot water supply is reset as a function of outside air temperature.

Table 6-1
EMCS Energy Savings Summary

Cooling System Energy Savings		Electrical (kWH/Yr) Savings
Building	**Option Description**	
451	Chiller Chilled Water Reset	3,285
451	Chiller Demand Limit	10.7 kW Less Demand
506	Chiller Water Reset	105,485
506	Chiller No. 2 Chilled Water Reset	47,815
2105	Chiller No. 1 Demand Limit	0, Critical Load
2105	Chiller No. 1 Chilled Water Reset	20,440
2105	Chiller No. 2 Chilled Water Reset	364
2105	Chiller No. 5 Chilled Water Reset	20,440
2105	Chiller No. 5 Demand Limit	0, Critical Load
3490	Chiller No. 1 Chilled Water Reset	4,015
3490	Chiller No. 2 Chilled Water Reset	730
3490	Chiller No. 3 Chilled Water Reset	15
3490	Chiller Nos. 1, 2 and 3 Demand Limit	26.1 kW Less Demand
3490	Optimal Chiller Selection (Manifold Chillers)	128,480
Total Electric Load Savings (kW)		**36.8 kW Less Demand**
Total Cooling System Power Savings (kWh)		**331,069**

Boiler System Energy Savings		Fuel (Million BTU/Yr)
451	Hot Water Boiler Outside Temperature Reset	LPG: 86.6 No. 2 Fuel Oil: 101.5
506	Hot Water Temperature Reset[1]	
2105	Hot Water Boiler Outside Temperature Reset	
3510	Hot Water Boiler Outside Temperature Reset	

Notes:
1. Includes portion of energy savings attributable to hot water temperature reset controls for the recommended modular hot water boiler system retrofit for Building 506.

Appendix A

Scope of Work and Minutes of Project Meetings

CEHND-ED-ME

September 1989

GENERAL SCOPE OF WORK

FOR AN

ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS

Performed as part of the

ENERGY ENGINEERING ANALYSIS PROGRAM

SCOPE OF WORK
FOR AN
ENERGY SURVEY OF ARMY BOILER AND CHILLER PLANTS

TABLE OF CONTENTS

E4 /

ANNEXES

1. BRIEF DESCRIPTION OF WORK: The Architect-Engineer (AE) shall:

1.1 Determine the efficiency of the boiler/chiller plants by appropriate tests.

1.2 Survey the boiler/chiller plants to determine if efficiency can be improved by the repair, addition, or modification of equipment, control systems and operation and maintenance practices and recommend improvements.

1.3 Identify all energy conservation opportunities (ECOs) in-

cluding low cost no cost items and perform complete evaluations of each.

1.4 Prepare programming documentation (DD Form 1391, Life Cycle Cost Analysis Summary Sheet with backup calculations and Project Development Brochure [PDB]) for any Energy Conservation Investment Program (ECIP) projects.

1.5 Prepare implementation documentation for all justifiable energy conservation opportunities.

1.6 Prepare a comprehensive report to document the work performed, the results and the recommendations.

2. GENERAL

2.1 Other studies performed under the Energy Engineering Analysis Program(EEAP) have been performed at the installation and may have included the boiler/chiller plants. Results of the previous studies concerning the boiler/chiller plants shall be included in this study. Boiler/chiller plant projects recommended in the previous studies shall be updated and included in this report if they have not been implemented or programmed. Any reports or studies that may have been accomplished on the boiler/chiller plants shall be reviewed by the AE and information included in this report as applicable.

2.2 The information and analysis outlined herein are considered to be minimum essentials for adequate performance of this study.

2.3 This study shall include a number of small boiler and chiller plants, all appurtenances, and supporting systems (e.g., fuel storage facilities, pollution abatement, water treatment, etc.). It does not include steam or chilled water distribution systems. However, if during the survey readily identifiable energy conservation opportunities pertaining to the distribution systems are noted, they shall be listed in the report.

2.4 The "Energy Conservation Investment Program (ECIP) Guidance," described in letter from CEHSC-FU, dated 25 April 1988, and revised in letter from CEHSC-FU-P, dated 15 June 1989, establishes criteria for ECIP projects and shall be used for performing the economic analysis of all projects or improvements considered. Construction cost escalation for DD Form 1391 submission shall be calculated using the guidelines contained in AR 415-17 and the latest Tri-Service MCP Index. The TRI-Service MCP Index, when updated, is contained in the latest applicable edition of the Engineer Improvement Recommendation System (EIRS) bulletin.

2.5 Energy conservation opportunities determined to be technically and economically feasible shall be developed into projects acceptable to installation personnel. This may involve combining similar ECOs into larger packages which will qualify for ECIP or MCA funding, and determining, in coordination with installation personnel, the appropriate packaging and implementation approach for all feasible ECOs. Energy conservation opportunities which do not fit into projects, such as operation procedure changes, shall be developed into detailed and specific instructions and procedures for operating personnel.

2.6 Projects which qualify for ECIP funding shall be identified, separately listed, and prioritized by the Savings to Investment Ratio (SIR).

2.7 All feasible non-ECIP projects shall be ranked in order of highest to lowest SIR.

2.8 Energy Conservation and Management (ECAM) projects for procurement-funded installations will be identified and analyzed using the same criteria as for ECIP. ECAM and ECIP will be considered synonymous in this Scope of Work.

3. PROJECT MANAGEMENT

3.1 Project Managers. The AE shall designate a project manager to serve as a point of contact and liaison for all work required under this contract. Upon the award of the contract, this individual shall be immediately designated in writing. The AE's designated project manager must be approved by the Contracting Officer prior to commencement of work. This designated individual shall be responsible for complete coordination of work required under this contract. The Contracting Officer will designate a project manager to serve as the Government's point of contact and liaison for all work required under this contract. This individual will be the Government's representative.

3.2 Installation Assistance. A coordinator (see DSOW) designated by the Commanding Officer at each installation will serve as the point of contact for obtaining available information and assisting in establishing contacts with the proper individuals and organizations as necessary to accomplish the work required under this contract.

3.3 Public Disclosures. The AE shall make no public announcements or disclosures relative to information contained or developed under this contract, except as authorized by the Contracting Officer.

3.4 Meetings. Meetings (see DSOW) will be scheduled whenever requested by the AE or the Contracting Officer for the resolution of questions or problems encountered in the performance of the work. The AE and or the designated representative(s) shall be required to attend and participate in all meetings pertinent to the work required under this contract as directed by the Contracting Officer. These meetings, if necessary, are in addition to the presentation and review conferences.

3.5 Site Visits, Inspections, and Investigations. The AE, consultants, if applicable, and or designated representative(s) thereof shall visit and inspect/investigate the site of the project as necessary and required during the preparation and accomplishment of the work.

3.6 Records

3.6.1 The AE shall provide a record of all significant conferences, meetings, discussions, verbal directions, telephone conversations, etc., with Government representative(s) relative to this contract in which the AE and or designated representative(s) thereof participated. These records shall be dated and shall identify the contract number, and modification number, if applicable, participating personnel, subject discussed and conclusions reached. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the records.

3.6.2 The AE shall provide a record of requests for and/or receipt of Government-furnished material, supplies, data, documents, information, etc., which if not furnished in a timely manner, would significantly impair the normal progression of work under this contract. The record shall be dated and shall identify the contract number and modification number, if applicable. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the record of request or receipt of material.

3.7 Interviews. The AE and the Government's representative shall conduct entry an exit interviews with the Director of Engineering and Housing before starting work at the facility and after completion of the field work. The Government's representative shall schedule the interviews at least one week in advance.

3.7.1 Entry. The entry interview shall thoroughly brief and describe the intended procedures for the survey and shall be conducted prior to commencing work at the facility. As a minimum, the interview shall cover the following points:

a. Schedules.

b. Names of energy analysts who will be conducting the survey.

c. Proposed working hours.

d. Support requirements from the Director of Engineering and Housing.

3.7.2 Exit. The exit interview shall include a thorough briefing describing the items surveyed and probable areas of energy conservation. The interview shall also solicit input and advice from the Director of Engineering and Housing.

4. SERVICES AND MATERIALS. All services, supplies, materials (except those specifically enumerated to be furnished by the Government), plant, labor, testing equipment, superintendence and travel necessary to perform the work and render the data required under this contract shall be included in the lump sum price of the contract.

5. PROJECT DOCUMENTATION. All energy conservation opportunities which the AE has considered shall be included in one of the following categories and presented as such in the report:

5.1 ECIP Projects. To qualify as an ECIP project, an ECO, or several ECOs which have been combined, must have a construction cost estimate greater than $200,000, a Savings to Investment Ratio greater than one and a simple payback period of less than eight years. For ECAM projects the $200,000 limitation may not apply. The AE shall check with the installation for guidance. The overall project and each discrete part of the project shall have a SIR greater than one. For all projects meeting the above criteria, complete programming documentation will be required. Programming documentation shall consist of a DD Form 1391, Life Cycle Cost Analysis Summary Sheet(s) (with necessary backup data to verify the numbers presented), and a project development brochure(PDB). A Life Cycle Cost Analysis Summary Sheet shall be developed for each ECO and for the overall project when more than one ECO is combined. For projects and ECOs updated or developed from the previous studies, the backup data shall consist of copies of the original calculations and analysis, with new pages revising the original calculations and analysis. In addition, the backup data shall include as much of the following as is available: the increment of work the project or ECO was developed under in the previous study, title(s) of the project(s), the energy to cost (E/C) ratio, the benefit to cost (B/C) ratio, the current working estimate (CWE), and the payback period. This information shall be included as part of the backup

a. Schedules.

b. Names of energy analysts who will be conducting the survey.

c. Proposed working hours.

d. Support requirements from the Director of Engineering and Housing.

3.7.2 Exit. The exit interview shall include a thorough briefing describing the items surveyed and probable areas of energy conservation. The interview shall also solicit input and advice from the Director of Engineering and Housing.

4. SERVICES AND MATERIALS. All services, supplies, materials (except those specifically enumerated to be furnished by the Government), plant, labor, testing equipment, superintendence and travel necessary to perform the work and render the data required under this contract shall be included in the lump sum price of the contract.

5. PROJECT DOCUMENTATION. All energy conservation opportunities which the AE has considered shall be included in one of the following categories and presented as such in the report:

5.1 ECIP Projects. To qualify as an ECIP project, an ECO, or several ECOs which have been combined, must have a construction cost estimate greater than $200,000, a Savings to Investment Ratio greater than one and a simple payback period of less than eight years. For ECAM projects the $200,000 limitation may not apply. The AE shall check with the installation for guidance. The overall project and each discrete part of the project shall have a SIR greater than one. For all projects meeting the above criteria, complete programming documentation will be required. Programming documentation shall consist of a DD Form 1391, Life Cycle Cost Analysis Summary Sheet(s) (with necessary backup data to verify the numbers presented), and a project development brochure(PDB). A Life Cycle Cost Analysis Summary Sheet shall be developed for each ECO and for the overall project when more than one ECO is combined. For projects and ECOs updated or developed from the previous studies, the backup data shall consist of copies of the original calculations and analysis, with new pages revising the original calculations and analysis. In addition, the backup data shall include as much of the following as is available: the increment of work the project or ECO was developed under in the previous study, title(s) of the project(s), the energy to cost (E/C) ratio, the benefit to cost (B/C) ratio, the current working estimate (CWE), and the payback period. This information shall be included as part of the backup

data. The purpose of this information is to provide a means to prevent duplication of projects in any future reports. For projects or ECOs the installation wants submitted as ECIP projects, complete programming documentation shall be prepared.

5.2 Non-ECIP Projects. Projects which normally do not meet ECIP criteria, but which have an overall SIR greater than one shall be individually packaged and fully documented. The Life Cycle Cost Analysis Summary Sheet shall be completed through and including line 6 for all projects or ECOs. Each shall be analyzed to determine if they are feasible even if they do not meet ECIP criteria. These ECOs or projects may not meet the nonenergy qualification test. For projects or ECOs which meet this criteria, the Life Cycle Cost Analysis Summary Sheet, completely filled out, with all the necessary backup data to verify the numbers presented, a complete description of the project and the simple payback period shall be included in the report. Additionally, these projects shall have the necessary documentation prepared, in accordance with the requirements of the Government's representative, for one of the following categories:

a. Quick Return on Investment Program (QRIP). This program is for projects which have a total cost not over $100,000 and a simple payback period of two years or less.

b. OSD Productivity Investment Funding (OSD PIF). This program is for projects which have a total cost of more than $100,000 and a simple payback period of four years or less.

c. Productivity Enhancing Capital Investment Program (PECIP). This program is for projects which have a total cost of more than $100,000 and a simple payback period of four years or less.

The above programs are described and documentation shall be prepared in accordance with AR 5-4, Change No.1.

d. Regular Military Construction Army (MCA) Program. This program is for projects which have a total cost greater than $200,000 and a simple payback period of eight to twenty-five years. Projects or ECOs which qualify for this program shall be economically analyzed in accordance with the requirements for Special Directed Studies in Engineering Technical Letter (ETL) 1110-3-332.

e. Low cost/no cost projects. These are projects that the Director of Engineering and Housing can perform with his resources.

5.3 Nonfeasible ECOs. All ECOs which the AE has considered

but which are not feasible, shall be documented in the report with the reasons and justifications showing why they were rejected.

6. DETAILED SCOPE OF WORK: The general Scope of Work is intended to apply to contract efforts for all Army boiler and chiller plants except as modified by the detailed Scope of Work for each specific installation. The detailed Scope of Work is contained in Annex B.

7. WORK TO BE ACCOMPLISHED

7.1 Determine Efficiency

7.1.1 Boilers. The efficiency of the existing boiler installation shall be determined by field testing. The AE shall provide equipment and perform tests in the field to establish the efficiency of the boilers. The tests are intended to determine the efficiency of the boilers as they are actually being operated. The AE shall document any changes made to controls or equipment during boiler efficiency tests. The AE shall submit the proposed test procedure and testing laboratory to the Contracting Officer for approval. Based upon the results of the tests, any indicated areas of improvement or equipment modification shall be fully analyzed. The study shall establish equipment operating data baselines, system efficiency modeling, and evaluate plant and unit loading profiles versus equipment capacities. The Government will furnish fuel, utilities, other consumables, and provide personnel to operate the plant during testing. All test and or measurement equipment shall be properly calibrated prior to its use.

7.1.2 Chillers. The efficiency of the existing chiller plant shall be analyzed and evaluated to determine if system efficiency can be improved or energy saving improvements implemented. The efficiency of the existing chillers shall be calculated using standard methods. Meters shall be used to obtain the necessary data to calculate efficiency. The AE is responsible for any metering necessary. If meters are existing, they may be used if their validated accuracy is within the limits specified below. If no meters are present, the AE is responsible for installing temporary meters. Permanent taps or connectors shall be installed so as to cause minimal disruptions to the system. Ultrasonic metering may be used. All meters used must have a recently calibrated accuracy of +-2 percent and a statement to that effect, signed by an independent testing laboratory must be included in the report. Efficiency tests shall be made at normal operating parameters.

7.2 Survey Existing Plants Lt an 2

7.2.1 The condition of the existing plant shall be studied, documented, and evaluated. Possibilities of repairing or replacing equipment or revising systems which will result in improved efficiency or reduced cost of operation shall be investigated.

7.2.2 The existing control system will be investigated, evaluated and documented to determine if equipment can be improved through upgrading, adjustment, repair or replacement, and if an alternate control system would increase efficiency. If an alternate system is recommended, interim improvements to existing controls shall also be recommended, if applicable. Engineering and economic analysis shall be developed. New controls proposed shall be Energy Monitoring and Control Systems (EMCS) compatible. Corps of Engineers Guide Specification (CEGS) 13946, Building Preparation for EMCS, shall be used as a standard for an interface to the existing plant. If an EMCS exists, interaction between this system and proposed modifications shall be clearly defined. The AE shall notify the DEH at least ten days prior to any pending outages of equipment and obtain concurrence prior to proceeding with any work.

7.2.3 The present boiler and chiller operation and maintenance practices shall be reviewed, documented, and evaluated with the intent to increase efficiency. The alternatives and recommendations shall be developed, evaluated, and documented in the report. Recommendations shall be in sufficient detail so that they can be quickly implemented. Detailed engineering and economic analysis of these actions are not required, however, a description and evaluation of these recommendations will be included in the report.

7.3 Identify ECOs. All methods of energy conservation which are reasonable and practical shall be considered, including operational methods and procedures and maintenance practices as well as physical facilities. A list of energy conservation opportunities is included as Annex D to this scope. This list is not intended to be restrictive but only to assure that at least these opportunities are considered, discussed and documented in the report. Each of the items shall considered and discussed in the report. Those items on the list which are not practical, have been previously accomplished, are inappropriate or can be eliminated from detailed analysis based on preliminary analysis shall be listed in the report along with the reason for elimination from further analysis. All potential ECOs which are not eliminated by preliminary considerations shall be thoroughly documented and evaluated as to the technical and economic feasibility. The AE shall provide all data and calculations needed to support the recommended ECO. All assumptions shall be clearly stated. Calculations shall be prepared showing how all numbers in the ECO were figured. Calculations shall be an orderly step-by-step progression from the first assumption to the final number. Descriptions of the products, manufacturers catalog cuts, pertinent drawings and sketches shall also be included. A Life Cycle Cost

Analysis Summary Sheet shall be prepared for each ECO and included as part of the supporting data.

7.4 Prepare Programming Documentation for ECIP Projects. For ECOs which meet ECIP criteria or ECOs which can be combined to meet ECIP criteria, complete programming documentation shall be prepared. Complete programming documentation consists of DD forms 1391, PDB, and supporting data. These forms shall be separate from the report. They shall be bound similarly to the final report in a manner which will facilitate repeated disassembly and reassembly.

7.4.1 Military Construction Project Data (DD form 1391). These documents shall be prepared in accordance with AR 415-15 and the supplemental requirements in Annex C. A complete DD Form 1391 shall be prepared for each project. The form shall include a statement that the project results from an EEAP study. Documents shall be complete as required for submission to higher DA headquarters. These programming documents will require review and signatures by the proper installation personnel. All documents shall be completed except for the required signatures.

7.4.2 Project Development Brochure (PDB). Preparation of the PDB requires the AE to delineate the functional requirements of the project as related to the specific site. The AE shall prepare PDBs in accordance with AR 415-20 and TM 5-800-3. Most projects will not require all the forms and checklists included in the Technical Manual (TM). Only that information needed for the project shall be included. The PDB-I format described in the TM shall be used for whatever information is needed.

7.5 Prepare Implementation Documentation. For feasible projects or ECOs which normally do not meet ECIP criteria, implementation documentation shall be prepared. Each feasible project or ECO shall be individually packaged and fully documented and included as a separate section in the volume containing the programming documentation. Each project or ECO shall have a complete description of the changes required, economic justifications, sketches, and other backup data included as a section in the report. The documentation required will be as determined by the Government's representative. Documentation required will be in the categories listed in paragraph 5.2. For the QRIP, OSD PIF and PECIP projects, documentation shall be prepared in accordance with the requirements of AR 5-4, Change No. 1. A sample implementation document, consisting of a DA Form 5108-R, sketches and manufacturers data and life cycle cost analysis summary sheet, shall be submitted for review and approval with the interim submittal. This sample shall be submitted and approved prior to the preparation of any other implementation documentation. To the degree possible, the project selected for the sample submission shall be typical of the majority of subsequent projects to be submitted. The sample shall consist of complete implementation documentation with

primary emphasis on format and manner of presentation rather than precise accuracy of cost estimate and energy saving data. For MCA projects the documentation required shall be in accordance with paragraph 7.4 except that the economic analysis required by ETL 1110-3-332 shall be included in lieu of the ECIP Life Cycle Cost Analysis. For low cost/no cost projects with the Director of Engineering and Housing personnel can perform, the following information shall be provided:

a. Brief description of the project.

b. Brief description of the reasons for the modification.

c. Specific instructions for performing the modification.

d. Estimated dollar and energy savings per year.

e. Estimated manhours and labor and materials costs. Costs shall be calculated for the current calendar year and so marked. Manhours shall be listed by trade. For projects that would repair an existing system so that it will function properly, also include the estimated manhours by trade and labor and material costs necessary to maintain the system in that condition. Some of the simple practical modifications may be developed on a per unit basis. An example of this type of modification would be the repair or replacement of steam traps on an as needed basis. As a rule, however, the AE should develop complete projects, if at all possible, rather than per unit modifications.

Separate sheets for each project showing the above information shall be prepared and included in the report.

7.6 Submittals, Presentations and Reviews. The work accomplished shall be fully documented by a comprehensive report. The report shall have a table of contents and be indexed. Tabs and dividers shall clearly and distinctly divide sections, subsections, and appendices. All pages shall be numbered. The AE shall give a formal presentation of all but the final submittal to installation, command, and other Government personnel. The AE shall prepare slides or view graphs showing the results of the study to date for his presentation. During the presentation, the personnel in attendance shall be given ample opportunity to ask questions and discuss any changes deemed necessary to the study. A review conference will be conducted the same day, following the presentation. Each comment presented at the review conference will be discussed and resolved or action items assigned. The AE shall provide the comments from all reviewers and written notification of the action taken on each comment to all reviewing agencies within three weeks after the review meeting. It is anticipated that each presentation and review conference will require approximately one working day. The

presentation and review conferences will be at the installation on the date(s) agreeable to the Director of Engineering and Housing, the AE and the Government's representative. The Contracting Officer may require a resubmittal of any document(s), if such document(s) are not approved because they are determined by the Contracting Officer to be inadequate for the intended purpose.

7.6.1 Interim Submittal. An interim report shall be submitted for review after completion of the field survey and an analysis has been performed on all of the ECOs. The report shall indicate the work which has been accomplished to date, illustrate the methods and justifications of the approaches taken and contain a plan of the work remaining to complete the study. Calculations showing energy and dollar savings and SIRs of all the ECOs shall be included. The simple payback period of all ECOs shall be calculated and shown in the report. The AE shall submit the Scope of Work and any modifications to the Scope of Work as an appendix to the report. A narrative summary describing the work and results to date shall be a part of this submittal. During the review period, the Government's representative shall coordinate with the Director of Engineering and Housing and provide the AE with direction for packaging or combining ECOs for programming purposes and also indicate the fiscal year for which the programming or implementation documentation shall be prepared. A sample implementation document (DA Form 5108-R, sketches and manufacturers data, life cycle cost analysis summary sheet and supporting data) for one project shall be submitted with this submittal for review and approval. The survey forms completed during this audit shall be submitted with this report. The survey forms only may be submitted in final form with this submittal. They should be clearly marked at the time of submission that they are to be retained. They shall be bound in a standard three-ring binder which will allow repeated disassembly and reassembly of the material contained within.

7.6.2 Prefinal Submittal. The AE shall prepare and submit the prefinal report when all work under this contract is complete. The AE shall submit the Scope of Work for the installation studied and any modifications to the Scope of Work as an appendix to the submittal. The report shall contain a narrative summary of conclusions and recommendations, together with all raw and supporting data, methods used, and sources of information. The report shall integrate all aspects of the study. The report shall include an order of priority by SIR in which the recommended ECOs should be accomplished. The synergistic effects of all of the ECOs on one another shall have been determined and the results of the original calculations adjusted accordingly. Completed programming and implementation documents for all recommended projects shall be included. The programming and implementation documents shall be ready for review and signature by the installation commander. The prefinal report, separately bound Executive Summary and all

appendices shall be bound in standard three-ring binders which will allow repeated disassembly and reassembly. The prefinal submittal shall be arranged to include (a) a separately bound Executive Summary to give a brief overview of what was accomplished and the results of this study using graphs, tables and charts as much as possible (See Annex D for minimum requirements), (b) the narrative report containing a copy of the Executive Summary at the beginning of the volume and describing in detail what was accomplished and the results of this study, (c) appendices to include the detailed calculations and all backup material and (d) the programming and implementation documentation. A list of all projects and ECOs developed during this study shall be included in the Executive Summary and shall include the following data from the Life Cycle Cost Analysis Summary Sheet: the cost (construction plus SIOH), the annual energy savings (type and amount), the annual dollar savings, the SIR, the simple payback period and the analysis date. For all programmed projects also include the year in which it is programmed and the programmed year cost.

7.6.3 Final Submittal. Any revisions or corrections resulting from comments made during the review of the prefinal report or during the presentation and review conference shall be incorporated into the final report. These revisions or corrections may be in the form of replacement pages, which may be inserted in the prefinal report, or complete new volumes. Pen and ink changes or errata sheets will not be acceptable. If replacement pages are to be issued, it shall be clearly stated with the prefinal submittal that the submitted documents will be changed only to comply with the comments made during the prefinal conference and that the volumes issued at the time of the prefinal submittal should be retained. Failure to do so will require resubmission of complete volumes. If new volumes are submitted, they shall be in standard three-ring binders and shall contain all the information presented in the prefinal report with any necessary changes made. Detailed instructions of what to do with the replacement pages should be securely attached to the replacement pages.

8. OPERATION AND MAINTENANCE INSTRUCTION. The AE shall prepare a one-day instructional course for the operation and maintenance personnel to explain possible energy saving potentials due to modified equipment and systems operation. The course will identify operational items noted during the study, which will effect energy conservation, and will explain the savings possible. A course outline or plan shall be submitted, with the prefinal submittal. Attendees at the course will be furnished appropriate handouts covering key points. This course will be held near the end of the study period at a time agreeable to the Government's representative and Director of Engineering and Housing personnel. This course is in addition to the formal review and presentations required.

ANNEX A

GENERAL ENGERY CONSERVATION OPPORTUNITIES

- Controls to assure proper combustion air-fuel ratio.
- Feedwater Treatment.
- Installation of new burner equipment.
- Economizer/air preheaters.
- Reduce excess air.
- Loading characteristics and scheduling versus equipment capacity (equipment optimization).
- Variable speed circulation pumps or alternate pumps based on seasonal loading.
- Steam pressure or hot water temperture reduction based on seasonal loading and/or existing and projected requirments.
- reduction in makeup water quantities.
- Evaluation of electric versus absorption chillers for replacement.
- Control system to operate chillers at their most efficient operating condition.
- Blowdown control.
- Common manifolding of chillers
- Prevent air leakage.
- Condenser/cooling tower water treatment.
- Variable or two-speed cooling tower fan.
- Free cooling cycle in lieu of chiller operation.
- Storage of chilled water.
- High efficient motors.
- Steam driving auxiliaries versus electric drives.
- Vaiable speed induced draft fans and forced draft blowers.
- Instruments and controls facilitate efficient operations.
- Variable volume pumping.
- Use of smaller boilers where load has been reduced.
- Correct sizing of traps.

- Replace inefficient boilers with more efficient boilers.
- Replace inefficient chillers with more efficient chillers.
- Replace existing fluorescent lighting ballats and lampss with more efficient lighting ballasts and lamps.
- Occupancy sensors to control lighting.
- Photocells to control lighting.
- Separate switches to control lighting arrangements.

CESPK-ED-M (415-10f)

5 May 1993
(Rev) 27 August 1993
DSOWCSYP/AA2

ANNEX B

DETAILED SCOPE OF WORK

SUBJECT: Energy Engineering Analysis Program (EEAP), FY93, Energy Survey of Army Boiler and Chiller Plants, Yuma Proving Ground, Yuma, Az.

CONTRACT NO. DACA05-C-92- 0155

A-E ADDRESS: Keller and Gannon
1453 mission Steet
San Francisco, California

POINT OF CONTACT: Messrs. Richard Lennig/Blair Horst

PHONE NO: (415) 621-1199 FAX NO: (415) 864-3681

1. Project Data:

1.1 Installation and Location: Yuma Proving Ground, Yuma, California

1.2 Study Title: Boiler and Chiller Plants Engergy Study

1.3 Project No. 099

1.4 Authorization: CEMP-ET Memorandum dated 25 Nov 92, Subject: Energy Engineering analysis Program (EEAP) - FY93 Program.

2. Project Description/Services:

a. Boiler and Chiller Plants Energy Study (BCPES): The work and services for this project require a energy survey, evaluation and analysis of Yuma Proving Ground boiler and chiller plants equipment, controls, and operations. The General Scope of Work (GSOW) (enclosure 1) describes and specifies the general requirements and procedures for conducting the study, documenting study finding and, preparation of study report.

b. This Detailed Scope of Work (DSOW) supplements the GSOW by identifying specific plants and systems to be investigated and/or studied. Should there be a conflict between the GSOW and the DSOW, the DSOW shall govern.

3. Projects and ECO's Evaluation and Survey:

3.1 Survey selected buildings chiller and air conditioning units/systems for impact (cost and effects on system performance) of conversion to non-Chlorinated Flurocarbon (CFC) based Refrigerants and Lubricants listed in Annex E.

3.2 Identify specific replacement non-chlorinated flurocarbon based refrigerants and lubricants recommended for existing chiller and air conditioning units.

3.3 Conduct an energy audit and survey of selected boiler and chiller plants listed in Annex E. The energy survey and audit shall be conducted as specified in the GSOW, except that temporary flow, pressure, temperature or power metering installation at chiller plants are not required to determine chiller efficiency. The audit shall include recommended adjustments for boilers, to increase boiler efficiency, and to test stack gases.

4. Projects and ECO's Evaluation/Survey:

4.1 Alternate 1: Temporary metering shall be installed to obtain flow, temperature, pressure, and power data to provide the necessary operating data to calculate efficiencies of chiller plants. Temporary metering shall be done using a non intrusive ultrasonic flow meter.

4.2 Alternate 2: Evaluate the concept and potential impact of controlling and operating the boiler and chiller plants with either a new or expanded, if existing, EMCS system.

4.3 Alternate 3: Investigate the feasibility and impact of replacing existing existing fluorescent lighting ballasts and lamps with energy efficienct lamps and ballasts for buildings included in boiler and chiller plants survey.

5. Submittals and Period of Services:

5.1 Interim (Preliminary) Report: The interim report is due one hundred twenty (120) calendar days after the receipt of the Notice to Proceed (NTP). The interim report format and presentation shall be as specified in the GSOW. (includes chiller instrumentation non-invasive)

5.2 Prefinal Report: The prefinal report is due seventy five (75) calendar days after the interim review conference. The prefinal submittal shall conform with the requirements of the GSOW (includes EMCS survey & evaluation, and Lighting survey & evaluation)

5.3 Final Report: Final report submittal shall be submitted and provided in accordance with requirements of the GSOW. The final report is due sixty (60) calendar days after the prefinal review conference.

5.4 Review conferences will be as specified in the GSOW and will be held at the installation. A pre-interim conference will be held to discuss and summarized the survey data obtained during the field investigation with the installation staff to develop guidance and consesus for assessing, organizing, and preparing the preliminary report.

5.5 Point of contact during the study is as noted below

a. Mr. Jack Nixon, DEH Engergy Coordinator, Yuma Proving Ground, (602) 328-2198.

b. Mr. Richard C. Lennig or Mr. Blair Horst, Keller and Gannon (A-E), San Francisco, CA, (415) 621-1199.

c. Nathaniel Hunter, Installation Support Section, Sacramento District, (916) 557-7413

5.6 Copies and distribution of submittals shall be as specified herein below:

a. US ARMY MATERIAL COMMAND (ATTN: AMCEN), 5001 Eisenhower Ave, Alexander, VA 22333-6000, one (1) copy.

b. Corps of Engineers, Mobile District, ATTN: CESAM-EN-CC (Mr. Tony Battaglia), P.O. Box 2288, Mobile, Alabama 36628-0001 one (1) copy.

c. Cdr. U.S. Army Yuma Proving Ground, ATTN: STRYP-EN (Mr. Jack Nixion, Yuma, Arizona 85365-9116 six (6) copies.

d. Corps of Engineers, Sacramento District, ATTN CESPK-ED-M (N. Hunter), 1325 J Street, Sacramento, California 95814-2922, four (4) copies.

7. <u>Government Furnished documentrs:</u>

(1) ETLs 1110-3-282, Energy Conservation, 1110-3-301, Entrance Doors to Heater/Boiler Rooms, 1110-3-318, Proedures for Programming Engery Monitoring and Control Systems (EMCS) Funded through MCA Program, and 1110-3-332, Economic Studies.

(2) Architectural and Engineering Instructions/Design Guide Criteria dated 9 December 1991.

(3) Energy Conservation Investment Program (ECIP) Guidance, dated 28 June 1991 and the latest revision with current energy prices and discount factors for life cycle cost analysis.

(4) TM 5-785, Engineering Weather Data, TM 5-800-2, General Criteria Preparation of Cost Estimates, and TM 5-800-3, Project Development Brochure, and TM 5-815-2, Energy Monitoring and Control Systems (EMCS).

(5) Information on Existing EMCS Studies, Design, Construction Contracts, or Operating Systems.

(6) AR 415-15, 1 Jan 84, Military Construction, Army (MCA) Program Development, Cost Estimating for Military Programming, AR 415-20, Construction, Program Development and Design Approval, and AR 5-4, Change No. 1, Department of the Army Productivity Improvement Program.

(7) The latest MCP Index.

(8) Available asbuilt drawings, property records, energy records, existing equipment data, fuel consumption records, etc.

(9) The latest applicable Engineer Improvement Recommendation System (EIRS bulletin.

(10) Example of correctly completed implementation document for project.

(11) EEAP, Basewide Energy System Plan, Yuma Proving Ground dated 3 September 1982.

(12) Electrical Distribution (Load Flow, Load Analysis, and Planning) Study, Yuma Proving Ground by U S Army Engineering and Housing Center, dated 22 July 1991.

A computer program titled "Life Cycle Costing in Design" (LCCID) is available from the BLAST Support Office in Urbana, Illinois for a nominal fee. This computer program can be used for performing the economic calculations for ECIP and non-ECIP ECOs. The BLAST Support Office can be contacted at 144 Mechanical Engineering Building, 1206 West Green Street, Urbana, Illinois 61801. The telephone number is (217) 333-3977 or (800) UI-BLAST."

N Hunter

NATHANIEL HUNTER
Project Manager

DISTRIBUTION:
A-E: Keller and Gannon (Mr. Lennig
ATZS-EH-E (Mr. Stein), Ft Hauchuca
CESAM-EN-CC (Mr. Battaglia), COE, Mobile Dist

PERIOD OF PERFORMANCE (From Post BCM Cover): The A-E shall submit the required data on the following schedule:

A. <u>REPORT:</u>

1. Interim - 120 calendar days after effective date of supplemental agreement.
2. Prefinal - 75 calendar days after the interim review conference.
3. Final - 60 calendar days after the prefinal review conference.

B. <u>CHILLER INSTRUMENTATION NON-INVASIVE</u> -concurrent with the interim submittal.

C. <u>EMCS SURVEY & EVALUATION AND LIGHTING SURVEY & EVALUATION</u> - concurrent with the prefinal submittal.

ANNEX C

REQUIRED DD FORM 1391 DATA

To facilitate ECIP project approval, the following supplemental data shall be provided:

a. In title block clearly identify projects as "ECIP."

b. Complete description of each item of work to be accomplished including quantity, square footage, etc.

c. Claims for boiler and chiller plants efficiency improvements must identify data to support present properly adjusted boiler operation and future expected efficiency. If full replacement of boilers is indicated, explain rejection of alternatives such as replace burners, nonfunctioning controls, etc. Assessment of the complete existing installation is required to make accurate determinations of required retrofit actions.

d. List references, and assumptions, and provide calculations to support dollar and energy savings, and indicate any added costs.

e. An ECIP life cycle cost analysis summary sheet as shown in the ECIP Guidance shall be provided for the complete project and for each discrete part included in the project. The SIR is applicable to all segments of the project. Supporting documentation consisting of basic engineering and economic calculations showing how savings were determined shall be included.

f. The DD Form 1391 face sheet shall include, for the complete project, the annual dollar and MBTU savings, SIR, simple payback period and a statement attesting that all buildings and retrofit actions will be in active use throughout the amortization period.

g. The calendar year in which the cost was calculated shall be clearly shown on the DD Form 1391.

h. The five digit category number for all ECIP projects except for Family Housing is 80000. The category code number for Family Housing projects is 71100.

i. Lighting retrofit projects must identify number and type of fixtures, and wattage of each fixture being deleted and installed. New lighting shall be only of the level to meet current criteria. Lamp changes in existing fixtures is not considered an ECIP type project.

ANNEX D

EXECUTIVE SUMMARY GUIDELINE

1. Introduction.

2. Boiler Data. (Number, sizes, efficiency,etc.)

3. Present Energy Consumption.

   o Total Annual Energy Used.

   o Source Energy Consumption.

   Electricity - KWH, Dollars, BTU
   Fuel Oil - GALS, Dollars, BTU
   Natural Gas - THERMS, Dollars, BTU
   Propane - GALS, Dollars, BTU
   Other - QTY, Dollars, BTU

   o Energy Consumption by Systems.

4. Historical Energy Comsumption.

5. Energy Conservation Analysis.

   o ECOs Investigated.

   o ECOs Recommended.

   o ECOs Rejected. (Provide economics or reasons)

   o ECIP Projects Developed. (Provide list)*

   o Non-ECIP Projects Developed. (Provide list)*

   o Operational or Policy Change Recommendations.

   o Recommended Boiler Air/Fuel Mix Setting (Based opon tes performed on stack gases emission.

* Include the following data from the life cycle cost analysis summary sheet: the cost (construction plus SIOH), the annual energy savings (type and amount), the annual dollar savings, the SIR, the simple payback period and the analysis date. For all programmed projects also include the year in which it is programmed and the programmed year cost.

6. Energy and Cost Savings.

   o Total Potential Energy and Cost Savings.

   o Percentage of Energy Conserved.

   o Energy Use and Cost Before and After the Energy Conservation Opportunities are Implemented.

7. Energy Plan.

- o Project Breakouts with Total Cost and SIR.
- O Schedule of Energy Conservation Implementation.

CESPK-ED-M (410-10f) 29 January 1993

ANNEX E

BUILDING LIST

SUBJECT: EEAP, Chiller Study, Yuma Proving Ground

BUILDING NO.	CAT. CODE	BLDG. DESCRIPTION	COOLING TONS
120			40*
451			50*
506B		ICE BANK	80
506C			200/150**
2105			40*/125 150/165***
3482			85*
3490			2-50* 1-100*

*MAY NOT BE A CHILLER UNIT
**STEAM BOILER
***SOLAR HEATING SYSTEM

CESPK-ED-M (415-10f) 11 February 1993

CONFERENCE MINUTES (DRAFT)

SUBJECT: Energy Engineering Analysis Program (EEAP), FY93, Energy Survey of Boiler and Chiller Plants, Yuma Proving Ground, Yuma Az.

1. A scope clarification was held at the Office of Keller and Gannon.(A-E) in San Francisco, California on 10 February 1993. The conference was held to clarify the study requirements and scope tasks. The persons in attendance below.

NAME	REPRESENTING	PHONE NUMBER
Mr. Richard Lennig	Keller and Gannon	(415) 621-1199
Mr. Blair Horst	Keller and Gannon	(415) 621-1199
Mr. Nathaniel Hunter	CESPK-ED-M/ISS, COE	(916) 557-7413

2. Both the Detailed Scope of Work (DSOW) and the General Scope of Work (GSOW) were reviewed. A summary of the conference is noted below:

a. It was pointed out that should their be conflict between the DSOW and the GSOW the DSOW will govern.

b. The A-E shall evaluate potential ECO's for building 2105 and systems served by existing solar energy plant with the goal of reducing HVAC loads to accommodate future expansion of HVAC system and facilities.

c. Report submittal and review conferences shall be as specified in the GSOW unless otherwise noted in the DSOW.

d. Measuring chiller efficiency shall be as described in the GSOW.

e. EMCS evaluation for controlling and operating boilers and chillers will be an optional task. Otherwise EMCS is not part of this study.

f. The A-E will advised the undersigned if his fee proposal exceeds $100,000 so additional option tasks may be identified.

NATHANIEL HUNTER
Technical Manager

cc:
A-E: Keller and Gannon (Messr Lennig and Horst)
DEH: STEYP-EH, Yuma Proving Ground (Mr. Jack Nixon)
TCX: CESAM EN-CC (Mr. Tony Battaglia)
Mil Proj Br, A-E Nego Sec
Mil Proj Br, ISS (Hunter)

RCL
for your file

Post-It™ brand fax transmittal memo 7671 | # of pages ▸ 4

To Nathaniel Hunter	From Blair Horst
Co. CESPK-EA-M/ISS	Co. Keller & Gannon
Dept.	Phone # (415) 621-1199
Fax # (916) 557-7865	Fax # (415) 864-3681

KELLER & GANNON
Engineers & Architects
Quality Services Since 1941

13 August 1992

MINUTES OF MEETING

AT: Yuma Proving Ground, Arizona

ON: 12 August 1992

SUBJECT: EEAP Limited Energy Study
Yuma Proving Ground, Arizona

THOSE PRESENT:

Name	Affiliation	Telephone No.
Nathaniel Hunter	CESPK-EA-M/ISS, Sacramento District	(916) 557-7413
Jack L. Nixon	U.S. Army, Yuma Proving Ground	(602) 328-2198
William Reed	U.S. Army YPG, J & J Corp.	(602) 328-3135
Blair Horst	Keller & Gannon	(415) 621-1199

ATTACHMENTS: General Scope of Work for an Energy Survey of Army Boiler and Chiller Plants (CEHND-ED-ME), dated September 1989 (revised, corrected printout) - annotated during meeting

1. The purpose of the meeting was to clarify the detailed scope of work for the subject project. The project will be funded either from FY92 or FY93 funds depending on availability and timing. The SOW for the Limited Energy Study at Fort Hunter-Liggett, California will be completed within the next week or two. Preparation of the SOW for this study will follow.

2. Mr. Hunter of the Corps of Engineers, Sacramento District summarized their special program to provide limited energy studies for various locations. The studies are intended to be planning tools; no design services will be performed under this contract.

3. Mr. Hunter mentioned that an ESOS type study for Fort Huachuca will be needed. He must first determine if K&G's contract can be used for this study. Mr. Horst stated that the contract language does not appear to preclude additional studies in other locations. Mr. Hunter said he will be checking into it and will inform K&G of the results.

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4. The original scope of work (SOW) for this study (attached) of the Yuma Proving Ground (YPG), proposed in 1989, addressed only chiller plants. The present SOW will be expanded to include boiler plants. DEH personnel at YPG will review the lists of boilers and chiller/compressors to update it and to identify smaller installations that may be deleted from the SOW. They will provide this information to Mr. Hunter.

5. It is the intent of this project that energy conservation projects for boiler and chiller plants and selected energy conservation opportunity (ECO) retrofits be evaluated and recommended. Funding request documentation will be prepared ready-for-signature.

6. The General SOW was discussed paragraph-by-paragraph. Changes and comments are indicated below:

   a. Paragraph 2.3: This paragraph will be deleted or modified. There are no extensive central plants with extensive distribution systems serving multiple buildings at YPG. A few plants extend services to adjacent buildings; these installations and their piping systems would be included. A few large buildings have one or more cooling plants. Distribution piping systems within these buildings will be considered, as appropriate.

   b. Paragraph 3.2: Jack L. Nixon, Energy Coordinator of YPG will be the P.O.C.

   c. Paragraph 3.4: An additional meeting or two may be needed during the course of field & engineering work for "over-the-shoulder" reviews. It was agreed that this could be addressed in K&G's cost proposal as "... attendance of up to n meetings at YPG ...".

   d. Paragraphs 3.7: Entry and exit briefings would be appreciated by YPG personnel. They will be brief and attended by the Energy Coordinator, DEH management and, possibly, the Deputy Base Commander.

   e. Paragraphs 7.1.1 & 7.1.2: Mr. Horst pointed out that the requirements of these paragraphs concerning ASME Test Code boiler efficiency tests and statements about instrument accuracies from independent testing laboratories could require the use of subcontractors, adding unneeded costs to the project. K&G uses hand-held oxygen and temperature instrumentation to determine boiler firing efficiency and assesses other losses using methods proven on several Basewide Energy Studies conducted under previous EEAP projects. Instruments are routinely calibrated. It was agreed that language requiring boiler testing per ASME Test Codes and requirements for independent test laboratory statements would be deleted from the SOW.

   f. Paragraph 7.2.2: Work concerning the Energy Monitoring and Control System (EMCS) will assume that the FM-signal based system may be repaired and expanded without compliance with the latest revision of CEGS 13946 which requires the use of fiber-optics

for signal transmission. Several documents were identified by Mr. Nixon that are pertinent to EMCS system design and/or retrofit:

CEND-SP-90-ED-ME, August 1990, Proposed Evaluation Guide for UEMCS/USAREUR Applications

CEHND-SP-91-249-ED-ME, September 1991, Standard Scope of Work and Design Checklists for EMCS Projects

TM 5-815-2, January 1991, EMCS Design Manual

Points of contact for the Army's EMCS program provided by Mr. Nixon are:

Mr. Terrance Houghton, Chief (202) 272-0427 or (205) 895-3324

Mr. George Evans, EMCS, HEMP-TEMPEST,EMI (202) 504-4914

Mr. Charles Holland (software expert) (205) 895-3338

The present FM signal-type EMCS system at YPG was upgraded about 7 years ago. It is presently used primarily to monitor the electric demand at two substations. Load shedding is programmed into field control units, but is not used extensively in order to avoid interfering with mission requirements. The system is an 177 Exiterm - Motorolla type system. Hardware and software system support are no longer available. At one time, as many as 60 receiver/transmitter locations were connected. Components have been removed or are disconnected. Most of the components are operable and are in storage pending reinstallation.

It was pointed out that DEH-YPG has requested a cost proposal from J & J Corp. to perform specific repairs and to expand services to new buildings from the existing EMCS system. This project will be included in the Energy Study and a funding document will be prepared for it.

g. Paragraph 7.2.3: Only a low level of detail is required in response to this requirement.

h. Paragraph 7.3 & Annex A: Several ECO's were deleted from consideration, including: Waste Heat Recovery, Use of Heavy Oils, Conversion of Steam Turbines to Electric Motors, Automatic Condenser & Chiller Tube Cleaners, Occupancy Sensors to Control Lighting, Photocells to Control Lighting, and Separate Switches to Control Lighting Arrangements.

The replacement of existing standard fluorescent lighting ballasts and lamps with energy efficient lamps and ballasts should be considered to reduce electric loads in buildings for which chiller surveys are to be conducted.

7. Additional Considerations: Mr. Nixon requested that the Energy Study address the following additional subjects:

   a. Environmental Permitting Considerations: Identify permit requirements, costs and schedule delays required for Environmental Assessments of proposed new construction should be addressed if the project requires a new building or structure. Such assessments include archeological investigations, for instance.

   b. Federal Requirements for Conversion to non-Chlorinated Fluorocarbon (CFC) based Refrigerants and Lubricants: The effects on system performance from changing to different refrigerants and lubricants should be incorporated into the study. Recommendations for specific replacement refrigerants and lubricants to be used in each type/size of chiller/compressor should be included.

   For Army policy, contact Dr. Chaing Sohn, Chief of the Army CFC Change-over Program at (800) USA-CERL for guidance.

8. Messrs. Hunter and Nixon discussed submittal addressees and numbers of copies required for each. A partial address list was compiled. Mr. Nixon will coordinate specifics directly with Mr. Hunter.

9. Heating system boilers and chiller/compressors included as an attachment to the General Scope of Work are up-to-date as of Summer 1992 according to Mr. Reed. Mr. Reed and Mr. Nixon will go over these lists to delete small systems from the study. DEH and J & J Corp maintain a list of chillers with manufacturer's names and capacities, but without model numbers. Model numbers are not included as many changes have been made throughout the years and units may no longer correspond to as-manufactured conditions.

10. YPG receives electric power from five (5) sources. The average cost is presently about 3 to 5 cents per KWH. While low, the cost of power above allocations from DOE sources is between 8 and 10 cents per KWH.

11. The Solar Energy - Absorption Cooling Plant and Ice Storage Cooling System will be included within the scope of this study.

Blair I. Horst

Blair I. Horst

16-403-10

cc: Mr. Nathaniel Hunter, CESPK-ED-M/ISS
U.S. Army Engineer District, Sacramento

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KELLER & GANNON
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13 October 1994

MINUTES OF MEETING

AT:	Directorate of Engineering & Housing, Yuma Proving Ground, AZ
ON:	11 October 1994, 0900
SUBJECT:	EEAP, FY93 Energy Survey of Boiler and Chiller Plants Yuma Proving Ground: Presentation of Prefinal Submittal, Discussions and Resolution of Review Comments Contract No. DACA05-C-92-0155
ATTACHMENTS:	(1) ARMS Output of Review Comments and Resolution Notes from Interim Submittal: Project QE102-EEAP Chiller Study at Yuma P.G. (2) Markup of Reference (c), Keller & Gannon Responses to Prefinal Submittal Review Comments
REFERENCES:	(a) Memorandum for Commander, U.S. Army Engineer District, Sacramento, Attn: CESPK-ED-M, from David R Tredrea, USAMC Installations and Services Activity, Rock Island, Illinois, dated 9 August 1994 (REVIEW COMMENTS) (b) Memorandum for Nat Hunter, CESPK-ED-M, USAED, Sacramento, CA, from Tony Battaglia, CESAM-EN-DM, USAED, Mobile Alabama, dated 17 August 1994 (REVIEW COMMENTS from Robert S. Woodruff, EN-DM) (c) Letter to Nathaniel Hunter, U.S. Army Corps of Engineers, Sacramento District, dated 7 October 1994 (K&G RESPONSES TO REVIEW COMMENTS)

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1453 Mission Street, San Francisco, California 94103
Phone: (415) 621-1199 FAX: (415) 864-3681
Mail: P.O. Box 422430, San Francisco, CA 94142-2430

THOSE PRESENT:

Name	Affiliation	Telephone No.
Nathaniel Hunter	CESPK-ED-M/ISS	916-557-7413
Blair I. Horst	Keller & Gannon	415-621-1199
Robert S. Woodruff	CE Mobile	205-694-4074
Jack Nixon	USAYPG	602-328-2198
Bob Green	USAYPG, DPW	602-328-2170
David Schmidt	PPG-EP&SP	602-328-3734
Foo Eng	CE-SPD	415-705-1459
Bruce Martz	Trane	602-358-9595

1. The purpose of the meeting was to present findings of the subject study and to discuss and resolve intended action on prefinal submittal review comments.

2. Mr. Horst presented the findings of the subject study. Mr. Bruce Martz of the Trane Corporation discussed refrigerants, the Montreal Protocol and other limits and measures that can be taken for compliance.

3. Mr. Hunter provided a copy of ARMS output of interim submittal review comments and their resolutions by Keller & Gannon; see Attachment (1). He also noted that Jack Nixon's (YPG) comments need to be transferred to ARMS access by Sacramento District—all Keller & Gannon responses were acceptable regarding YPG comments. Mr. Hunter will see that they are input into ARMS.

4. Following the presentation, Messrs. Hunter, Nixon, Woodruff, Green, Eng and Horst discussed the Reference (a) and (b) review comments and the Reference (c) responses from Keller & Gannon. All Keller & Gannon responses were accepted (see Attachment (2)) with the exception of the following clarifications:

   Reference (a), comment 1a: Keller & Gannon will not be asked to reorganize project bundles. Mr. Horst agreed to provide copies of selected computer spreadsheet energy conservation opportunity calculation files for use by Jack Nixon.

Reference (b), comment 1e: Calculations for ECOs B4A and B4B will be revised for existing operator attendance of three hours per day, five days per week. Text will be modified accordingly.

5. Mr. Nixon stated that he had numerous local (YPG) personnel review the prefinal submittal. He and his reviewers have no comments.

6. Mr. Hunter stated that there are no additional comments from Sacramento District, Corps of Engineers.

7. Revised pages will be distributed, as the final submittal, to addresses of the prefinal submittal with instructions for their insertions and removals of obsolete sheets.

8. Mr. Hunter informed the assembled that he has taken an opportunity for "early retirement." He will leave government service after next week. He does not know yet who will be assigned to cover his other projects.

Blair I. Horst

Blair I. Horst

BIH:az
16-403-11

Copy without Attachments to:

Mr. Nathaniel Hunter
CESPK-ED-M/ISS
Corps of Engineers, Sacramento District

Project: QE102 - EEAP CHILLER STUDY at YUMA P.G
Review: INTERIM REVIEW

#	Reviewer	Location	Discipline

==

1 JENSEN VOL I-PAR 1 MEC
---- Erik Jensen (RV) COM: (916) 557-7661
---- Routing: 1<--JENSEN<--MECH<--DQA<--HUNT

] Vol 1 para 1, Executive Summary: Provide a summary as
] stated in prefinal report. We presume the summary will
] contain a listing of the different types of projects
] developed and their disposition,i.e.recommended/not
] recommended for implementation. Pleassemake this summary as
] brief as possible.
] >A/E Response: DONE
]
] Done. Executive Summary is provided in
] the Prefinal Submittal.

==

2 JENSEN VOL I-PAR 1 MEC
---- Erik Jensen (RV) COM: (916) 557-7661
---- Routing: 2<--JENSEN<--MECH<--DQA<--HUNT

] Vol 1 para 3.3Boiler Plant: In this para or in superceding
] para (List para number) explain
] a) The type fuel requirement for the boilers, i.e. which
] ones of the boilers are fired with LPG and which ones are
] fired with No.2 fuel oil, or if one fuel is the primary and
] the other the standby (secondary). Please explain this, and
] elaborate on the usage.
] b) That the steam is usaed to heat hot-water(HW) in a heat
] exchanger located in individual buildigs.
] >A/E Response: DONE
]
] Done. a) See Section 3.3, revised, and
] Table 4-2. b) Clarified, see Section
] 3.3, revised.

Received from
Net Hunter 11 Oct 94
BA

ATTACHMENT 1

```
 #       Reviewer                    Location                 Discipline

==========================================================================
3        JENSEN                      VOL I-PAR 1              MEC
    ----     Erik Jensen (RV)                        COM: (916) 557-7661
    ----     Routing:  3<--JENSEN<--MECH<--DQA<--HUNT
        ______________________________________________________

   ] Vol 1, para 4.4.1 Building 506 Boiler Plant; project
   ] B1-High efficiency burners including oxygentrim controls:
   ]  a) Define the term "Firing Efficieny". If this is the same
   ] as Combustion Efficiency,so state.
   ]  b) 85 percent efficiency seems high.It may be obtained for
   ] oil fired boilers at high firing rate and with a perfect
   ] air-fuel ratio. 80-83 percent is more reasonable. Gas fired
   ] boilers will normally not exceedapproximately 75 %
   ] efficiency. Please provide rationale, and change efficiency
   ] as needed.
   ]  >A/E Response: DONE
   ]
   ] Done. a) Yes, see Section 4.4.1 and
   ] Appendix C, revised and Table 4-2. b)
   ] Yes, see Appendix C, revised and Table
   ] 4-2.

==========================================================================
4        JENSEN                      VOL I-TABLE 4-2          MEC
    ----     Erik Jensen (RV)                        COM: (916) 557-7661
    ----     Routing:  4<--JENSEN<--MECH<--DQA<--HUNT
        ______________________________________________________

   ] Vol 1, Table 4-2. Recommend energy conservation
   ] opportunities: See prior comment regarding oil (Destillate)
   ] and LPG usage. Add by footnote how each is used.
   ]  >A/E Response: DONE
   ]
   ] Done. See Table 4-2 footnote.
```

Project: QE102 - EEAP CHILLER STUDY at YUMA P.G
Review: INTERIM REVIEW

#	Reviewer	Location	Discipline

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5 JENSEN VOL I-TABLE 6-1 MEC
---- Erik Jensen (RV) COM: (916) 557-7661
---- Routing: 5<--JENSEN<--MECH<--DQA<--HUNT

] Vol 1, Table 6-1: Explain below this table or in any other
] appropriate location (List where) that replacing steam
] boilers with hot watwr boilers was considered, aand was/was
] not a viable option and why.
] >A/E Response: DONE
]
] Done. HW boiler conversion found
] economic at Building 506. Portion of
] fuel savings attributable to HW reset
] controls is added to EMCS savings shown
] on Table 6-1.

===

6 JENSEN VOL 1-APPX A MEC
---- Erik Jensen (RV) COM: (916) 557-7661
---- Routing: 6<--JENSEN<--MECH<--DQA<--HUNT

] Vol 1, Appendix A:
] a) In para 1.4 list location of A-E prepared DD Form 1391
] b) In para 2.3 list where the smaller Boiler and Chiller
] scenarios are presented as mentioned.
] c) In para 2.3 also discuss the condition of the steam
] distribution system (List where to be found in this
] report). Oftentimes the insulation of the underground steam
] lines might be in poor condition resulting in huge heat
] (energy) losses.
] >A/E Response: NOT_DONE
]
] Not done. a) Refer to next submittal.
] b) The only boilers evaluated per the
] DSOW (see Appendix A) are in building
] 506. These boilers serve only Building
] 506. There are no underground steam
] lines.

#	Reviewer	Location	Discipline

7 JENSEN VOL 1-APPX A MEC
---- Erik Jensen (RV) COM: (916) 557-7661
---- Routing: 7<--JENSEN<--MECH<--DQA<--HUNT

] Vol 1, Appendix A: In para 7.1.2 chillers, clarify
] statement "The efficiency of the existing chillersshall be
] calculated using standard methods" i.e. define the
] efficiency and at what points measurements were taken.
] >A/E Response: DONE
]
] Done. Methodology of data monitoring
] and efficiency calculations are
] addressed in revised Appendix E, page
] E-1, "Introduction."

8 JENSEN VOL 1-APPX A MEC
---- Erik Jensen (RV) COM: (916) 557-7661
---- Routing: 8<--JENSEN<--MECH<--DQA<--HUNT

] Vol 1, Appendix A: Paras 1-8 are duplicated. Please remove
] one (1) set.
] >A/E Response: DONE
]
] Done. The second copy of GSOW,
] paragraphs 1-8 will be removed for the
] next submittal.

Project: QE102 - EEAP CHILLER STUDY at YUMA P.G
Review: INTERIM REVIEW

#	Reviewer	Location	Discipline

==

9 JENSEN VOL 1-APPX D MEC
---- Erik Jensen (RV) COM: (916) 557-7661
---- Routing: 9<--JENSEN<--MECH<--DQA<--HUNT

] In sect. "Combustion Efficiency" we recommend that a
] Boiler Tune-Up (BTU) program be initiated by the Owner or
] cotracted out. Please mention. A BTU program will normally
] result in boilers yielding optimum combustion efficiencies
] at different loads. Substantial fuel (energy) savings might
] be realized.
] >A/E Response: DONE
]
] Done. The BTU program is now mentioned
] in the Report Section 4.4.1. Appendix
] D contains only the method used to
] assess boiler plant efficiency based on
] combustion efficiency.

==

1 LUM E-00 ELE
---- Franklin Lum (RV) COM: (916) 557-7221
---- Routing: 1<--LUM<--ELEC<--DQA<--HUNT

] No electrical comment for the study at interim review.
] >A/E Response: DONE
]
] Done. Noted.

==

1 HAVEN 0-0 GEN
---- Laura Haven (RV) COM: (916) 557-7651
---- Routing: 1<--LAURA<--MECH<--DQA<--HUNT

] No comments
] >A/E Response: DONE
]
] Info.

#	Reviewer	Location	Discipline

==

1 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 1<--SPKEDMI<--HUNT

] GENERAL: THIS A VERY GOOD INTERIM SUBMITTAL. IT HAS A
] GOOD APPROACH ON THE ANALYSIS, AND THE REPORT IS WELL
] DOCUMENTED.
] >A/E Response: DONE
]
] Noted. Thank you.

==

2 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 2<--SPKEDMI<--HUNT

] PG2-1: INCLUDE THE CFC AND EMCS WORK IN THE SUMMARY OF THE
] SCOPE OF WORK.
] >A/E Response: DONE
]
] Done. A description of CFC and EMCS
] work will be added to the summary of
] the SOW.

==

3 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 3<--SPKEDMI<--HUNT

] PG 2-1, PAR 2.2: IN THE FIFTH ITEM, CHANGE "CONSUMPTION" TO
] "CONSERVATION".
] >A/E Response: DONE
]
] Done. The typographical error will be
] corrected.

Project: QE102 - EEAP CHILLER STUDY at YUMA P.G
Review: INTERIM REVIEW

#	Reviewer	Location	Discipline

4 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 4<--SPKEDMI<--HUNT

] PG 4-1, PAR 4.1.2.1: DEMAND CHARGES SHOULD BE MENTIONED
] HERE. EITHER DISCUSS THE DEMAND CHARGES IN THIS PARAGRAPH
] OR REFER TO A SEPARATE DISCUSSION.
] >A/E Response: DONE
]
] Done. Demand charges are addressed in
] the paragraph noted.

5 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 5<--SPKEDMI<--HUNT

] PG 4-6: IN THE PARAGRAPH ON DUTY CYCLE CONTROLS, 5TH LINE,
] THERE IS EITHER A TYPO OR SOMETHING LEFT OUT OF THE
] SENTENCE. PLEASE CLARIFY.
] >A/E Response: DONE
]
] Done. The subject paragraph has been
] modified.

6 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 6<--SPKEDMI<--HUNT

] PG 4-8: IN THE DISCUSSION ON OCCUPANCY SENSORS, A SAVING
] OF 25% WAS ASSUMED BASED ON ARIZONA PUBLIC SERVICE
] EXPERIENCE. pLEASE PROVIDE ADDITIONAL BACKUP ON
] APPLICABILITY OF THEIR RESULTS TO THIS SITUATION.
] >A/E Response: DONE
]
] Done. Additional justification of this
] 25% figure is provided in the subject
] paragraph.

Project: QE102 - EEAP CHILLER STUDY at YUMA P.G
Review: INTERIM REVIEW

#	Reviewer	Location	Discipline
7	BATTAGLIA	CESAM	ENERGY
----	Mil Proj Mgt Sec ISS (RV)		COM: (916) 557-7407
----	Routing: 7<--SPKEDMI<--HUNT		

] PG 4-9: IN TABLE 4-9, COLUMN FOR SIR > 1.0: CORRECT COLUMN
] HEADING.
] >A/E Response: DONE
]
] Done. Subject column heading is
] corrected.

#	Reviewer	Location	Discipline
8	BATTAGLIA	CESAM	ENERGY
----	Mil Proj Mgt Sec ISS (RV)		COM: (916) 557-7407
----	Routing: 8<--SPKEDMI<--HUNT		

] PG 4-10: THIS IS A VERY GOOD SUMMARY TABLE.
] >A/E Response: DONE
]
] Noted. Thank you.

#	Reviewer	Location	Discipline
9	BATTAGLIA	CESAM	ENERGY

---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 9<--SPKEDMI<--HUNT

] PG 6-1: SECTION 6.0, ENERGY MONITORING AND CONTROL SYSTEM
] EVALUATION: THE FOLLOWING COMMENTS WILL REQUIRE SOME
] ADDITIONAL WORK; BUT, IN MY OPINION, IT WOULD BE CONSISTENT
] WITH ALTERNATE 2 IN THE DETAIL SCOPE OF WORK FOR EVALUATING
] THE CONCEPT OF AN EMCS.
]
] A. PROVIDE A DESCRIPTION OF THE PROPOSED SYSTEM TO INCLUDE
] THE CENTRAL OPERATOR STATION (COS) AND THE DATA
] TRANSMISSION MEDIUM (PHONE LINE, DEDICATED WIRELINE, FIBER
] OPTIC, RADIO FREQUENCY, OR COMBINATION.
]
] B. FAMILY HOUSING IS USUALLY HANDLED WITH AN FM SYSTEM TO
] TURN AIR CONDITIONING UNITS ON OR OFF IN CONJUNCTION WITH A
] DEMAND LIMITING PROGRAM. PLEASE DISCUSS HOW THIS WOULD BE
] INTERGRATED WITH THE REST OF THE SYSTEM.
]
] C. COST ESTIMATE SHOULD ALSO INCLUDE COSTS FOR A CENTRAL
] OPERATOR STATION AND THE DATA TRANSMISSION MEDIA.
] >A/E Response: DONE
]
] Done. a) Requested elements are added.
] b) Description of proposed central
] operator station and data transmission
] system has been provided. c) The cost
] estimate is revised.

#	Reviewer	Location	Discipline
10	BATTAGLIA	CESAM	ENERGY

---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 10<--SPKEDMI<--HUNT

] APPENDICES: NUMBER PAGES IN THE APPENDICES.
] >A/E Response: DONE
]
] Done. Pages in all appendices will be
] numbered.

#	Reviewer	Location	Discipline

---

11 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 11<--SPKEDMI<--HUNT

] APPENDIX A: MY VOLUME I HAD TWO COPIES OF THE GENERAL
] SCOPE OF WORK. ONE IS SUFFICIENCT FOR FUTURE SUBMITTALS.
] >A/E Response: DONE
]
] Done. The second copy of GSOW,
] paragraphs 1-8 will be removed for the
] next submittal.

---

12 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 12<--SPKEDMI<--HUNT

] APPENDIX C: LCCA SUMMARY SHEETS FOR BOILER ECOS: IN COLUMN
] 2.(1), HEADING SHOULD BE"$/MBTU" AND TOTAL SAVINGS SHOULD
] BE ON LINE "F" RATHER THAN LINE "E".
] >A/E Response: DONE
]
] Done. Column heading and title are
] corrected.

---

13 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 13<--SPKEDMI<--HUNT

] APPENDIX E: INSTRUMENTATION/DATA COLLECTIO: INCLUDE
] MANUFACTURER'S NAME FOR FLOW METER.
] >A/E Response: DONE
]
] Done. The manufacturer's name/model
] number have been added to the
] description.

Project: QE102 - EEAP CHILLER STUDY at YUMA P.G
Review: INTERIM REVIEW

#	Reviewer	Location	Discipline
14	BATTAGLIA	CESAM	ENERGY

---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 14<--SPKEDMI<--HUNT

] APPENDIX F: CHILLED WATER RESET, EXPLANATION OF ANALYSIS:
] THE COMMENTS ARE GENERAL; THEY APPLY TO THIS ANALYSIS FOR
] EACH APPLICABLE BUILDING.
]
] A. THE NARRATIVE MENTIONED THE SPREAD SHEET AND GRAPHICAL
] ANALYSIS. THESE SHOULD FOLLOW,THE NARRATIVE.
]
] B. THE GRAPHICAL ANALYSIS MENTIONED ABOVE COULD NOT BE
] FOUND. INCLUDE IT AND LABEL IT, OR DELETE THE REFERENCE.
]
] C. CLARIFY THE DEFINITIONS OF ABBREVIATIONS. EXAMPLES
] FOLLOW:
]
] 1) T(W/R SUBSTRIP) AND DELTA T: IS ONE OF THESE
] SUPPOSED TO BE (CHW RETURN TEMP - CHW SUPPLY TEMP)? IS ONE
] SUPPOSED TO BE THE RESET INCREMENT?
]
] 2) COOLING HOURS: THIS SOUNDS LIKE A TERM THAT WOULD
] HAVE THE DIMENSION OF TIME, EG, HOURS; BUT THE DEFINITION
] APPEARS TO BE A DIMENSIONLESS NUMBER.
]
] 3) ARE LOGIC STATEMENTS SUPPOSED TO READ AS FOLLOW? IF
] EER>0, THAN KW= BTUH/EER 1000 X (COOLING HOURS).
] >A/E Response: DONE
]
] Done. a) Chiller ECOs are reorganized
] as suggested. b) Chiller ECOs are
] reorganized as suggested. c)
] Abbreviations are explained with more
] detail; the term is changed to "Cooling
] Factor;" and logical statements are
] clarified.

#	Reviewer	Location	Discipline

15 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 15<--SPKEDMI<--HUNT

] APPENDIX F: UNNUMBERED TABLE, "SUMMARY OF CHILLER
] RECOMMENDATIONS": THIS TABLE NEEDS AN IDENTIFYING NUMBER,
] AND THE TITLE SHOULD INDICATE WHICH ECO IT IS FOR.
] >A/E Response: DONE
]
] Done. The table will be numbered and
] ECO to which it pertains will be
] indicated.

16 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 16<--SPKEDMI<--HUNT

] APPENDIX F: EVAPORATIVE PRECOOLING OF AIR-COOLED CHILLER
] CONDENSER COOLING AIR: INCLUDE THE LCCA SUMMARY SHEET AND
] REFERENCE THE LOCATION OF THE ENERGY SAVINGS CALCULATIONS.
] >A/E Response: DONE
]
] Done. The LCCA Summary Sheet will be
] provided and energy savings
] calculations will be provided in an
] easily found location.

17 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 17<--SPKEDMI<--HUNT

] APPENDIX F: SPREED SHEED FOR INDIRECT EVAPORATIVE
] PRECOOLING OF CONDENSER AIR; TENTH LINE DOWN, FOR AMBIENT
] TEMP OF 77F: ARE THE CAPACITIES IN TONS FOR DRY BULB
] OPERATION AND PRE-COOLED OPERATION SWITCHED?
] >A/E Response: DONE
]
] Done. The spreadsheet calculation is
] corrected.

#	Reviewer	Location	Discipline

18 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 18<--SPKEDMI<--HUNT

] APPENDIX F: PROVIDE IDENTIFYING NUMBERS AND TITLES FOR
] THE ENERGY SAVINGS CALCULATIONS SPREAD SHEETS.
] >A/E Response: DONE
]
] Done. Identifying numbers and titles
] for the energy savings calculation
] spreadsheets will be provided.

19 BATTAGLIA CESAM ENERGY
---- Mil Proj Mgt Sec ISS (RV) COM: (916) 557-7407
---- Routing: 19<--SPKEDMI<--HUNT

] APPENDIX I: ENERGY MONITORING AND CONTROL SYSTEM
] CALCULATIONS.
]
] A. THE ANALYSIS APPEARS TO STOP IN MIDSTREAM ON PAGE I-3.
] PLEASE INCLUDE THE REST OF THE ANALYSIS IN THE NEXT
] SUBMITTAL.
]
] B. ESTIMATE: REFER TO RIUS AS REMOTE TERMINAL UNITS, AS
] PREVIOUSLY DEFINED ON PAGE I-5.
]
] C. ESTIMATE: INCLUDE COSTS FOR CENTRAL OPERATOR STATION
] AND DATA TRANSMISSION MEDIA.
] >A/E Response: DONE
]
] Done. a) Analysis is clarified. b)
] "Transmitter" is changed to "Terminal"
] in all EMCS cost estimates. c) Costs of
] the COS and Data Transmission Media are
] included.

KELLER & GANNON
Engineers & Architects
Quality Services Since 1941

7 October 1994

U.S. Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, CA 95814-2922

Attention: Mr. Nathaniel Hunter
Installation Support Section

Subject: Contract No. DACA05-C-92-0155
EEAP, FY93, Energy Survey of Boiler and Chiller Plants
Yuma Proving Ground, Arizona
Responses to Review Comments on Prefinal Submittal

Dear Mr. Hunter:

Responses to comments on Prefinal Submittal: EEAP Survey of Boiler and Chiller Plants, Yuma Proving Ground, Arizona are as follows:

Comments from USAMC Installations and Services Activity (Reference AMXEN-C(11b.), dated 9 August 1994):

Comment 1a. Disagree: A revision of project funding methodology is not within the scope of work for this stage of the project. Agreements were reached following submittal of the Interim Submittal concerning preparation of the required funding documentation.

ok

Comment 1b. Agree: The LCCA summary format followed guidance which was current when the Notice to Proceed was issued and the Interim Submittal was prepared. The new format will be incorporated in the final DD Form 1391 document.

ok

Comment 1c. Agree: Current discount factors (October 1993 edition of NISTIR 85-3273-6) were incorporated. No results and recommendations will change by revising economic lives of HVAC and boiler plant retrofits from 15 years to 20 years and EMCS HVAC controls retrofits from 15 years to 10 years. The new economic life-times will be used in the final DD Form 1391 document.

ok

Comment 1d. Agree: The typographic error will be corrected: "HCFC-134a" will be changed to read "HFC-134a."

ok

\1640311\10-07lt1.bih
941006-2

1453 Mission Street, San Francisco, California 94103
Phone: (415) 621-1199 FAX: (415) 864-3681
Mail: P.O. Box 422430, San Francisco, CA 94142-2430

ATTACHMENT 2

Comment 1e. Agree: However, the steam boilers are attended almost continuously. Page 4-4 will be revised to state that the boilers are not continuously attended, but rather, are attended during the day shift, five days per week, each 3 hours per day. Modular boiler calcs will be modified correspondingly.

ok as modified

Comment 1f. Agree: Detailed designers of this project should be directed to select boilers with minimum output versus input of 80%. Evaluations in this report are conceptual and proposed only in enough detail to determine economic viability of the proposed retrofit.

ok

Comment 1g. Disagree: Evaluation of harmonics added to electrical systems is beyond the scope of this project. However, please note that all electronic ballasts are selected for total harmonic distortion (THD) of the current wave form of less than 10%, which is no worse than the THD generated by existing core-and-coil magnetic ballasts.

ok

Comment 2. Noted.

Comment 3. Noted.

Comments from Mr. Robert S. Woodruff, EN-DM, Mobile District Office of Project Review Comments, dated 11 August 1994.

Comment 1. Agree: Corrections will be made to the text.

ok

Comment 2. Agree: Corrections will be made to the text.

ok

Comment 3. Agree: ECO item E will be added to the table on page 1-5 and on other summaries as appropriate.

ok

Comment 4. Agree: Please refer to Table 3-1. An explanation will be provided in Table 1-4.

ok

Comment 5. Agree: Arizona Public Service Co. has a demand charge. However, a rate which includes both the demand charges and energy usage charges is used in evaluations of most ECO's; refer to page 4-2. This was done as directed by the Yuma Proving Ground Energy Coordinator.

ok

Comment 6. Agree: Detailed design of the modular boiler retrofit should include a computer simulation of energy use, heating and cooling loads. Calculations provided in the subject study provide preliminary sizing based on modifications made to the building since it was originally

ok

constructed, and on standard design practices for boiler systems. Detailed computer modeling is beyond the scope of work for this study.

Comment 7. ok ✓ Agree: The energy efficiency ratio (EER) is determined based on measured data for a minimum of 24 hours.

Please contact me or Mr. Blair Horst if you have any questions or comments.

Very truly yours,

Richard Lennig

Richard C. Lennig
Vice President

RCL:vb
16-403-11
via Hand Delivery

DEPARTMENT OF THE ARMY
USAMC INSTALLATIONS AND SERVICES ACTIVITY
ROCK ISLAND, ILLINOIS 61299-7190

REPLY TO
ATTENTION OF

KELLER & GANNON
RECEIVED
OCT 05 1994

09 AUG 1994

AMXEN-C (11b)

MEMORANDUM FOR Commander, U.S. Army Engineer District, Sacramento, ATTN: CESPK-ED-M, 1325 J Street, Sacramento, CA 95814-2922

SUBJECT: Energy Engineering Analysis Program (EEAP) Survey of Boiler and Chiller Plants, Yuma Proving Ground, Arizona

1. The subject EEAP survey has been reviewed by this office and the following comments are provided:

a. Recommend the eight individual project items be submitted separately for funding under the Federal Energy Management Program (FEMP).

b. The Life-Cycle Cost Analysis summaries utilized an incorrect format. Ensure format used is IAW current Energy Conservation Investment Program (ECIP) guidance.

c. Ensure discount factors utilized are up-to-date and the economic life of each project is IAW ECIP guidance (i.e., 10 years for Energy Management Control Systems, 20 years for boiler plant modifications and heaving ventilating, and air-conditioning, etc.).

d. On page 1-6, change HCFC-134a to HCF-134a. — HFC-134a

e. Page 4-4 states boilers are to be continuously attended. Boilers of that small size normally do not require continuous attendance.

f. The boiler modules shown on page C-122 have low efficiency. Recommend specifying a minimum BTU output/BTU fuel input of 80 percent.

g. Appendix H, page 63, indicates lighting retrofits are to utilize electronic ballasts. Extensive retrofits utilizing electronic ballasts (although energy efficient) could potentially alter the K-rating of existing transformers. Recommend the harmonics added to the electrical system (due to electronic ballasts retrofit) be analyzed.

2. We are available for further assistance. The points of contact are Messrs. John Nache and Joe Cibulka, AMXEN-C, DSN 793-4652/8266, respectively.

09 AUG 1994

AMXEN-C
SUBJECT: Energy Engineering Analysis Program (EEAP) Survey of Boiler and Chiller Plants, Yuma Proving Ground, Arizona

3. AMC -- America's Arsenal for the Brave.

FOR THE COMMANDER:

David R. Tredrea

DAVID R. TREDREA, D.Sc.,
Chief, Facilities Engineering
and Construction Division

CF:
Cdr, AMC, ATTN: AMCEN-A
Cdr, YPG, ATTN: STEYP-PW-P
Cdr, USAED-Mobile, ATTN: Mr. T. Battaglia

FACSIMILE HEADER SHEET

COMMAND/OFFICE	NAME/OFFICE SYMBOL	OFFICE PHONE	FAX
From: USAED Mobile, AL	Tony Battaglia CESAM-EN-DM	(205) 690-2618	(205) 690-2424
To: USAED Sacramento, CA	Nat Hunter CESPK-ED-M	(916) 557-7413	(916) 557-7865

CLASS	PREC	PAGES	DATE-TIME	MO	YR	RELEASER'S SIGNATURE
U	N	2	17 0730	08	94	Anthony W. Battaglia

REMARKS

space below for communications center use only

Nat:

Attached are our comments on the Yuma Boiler/Chiller study.

Tony B.

MOBILE DIST. OFFICE PROJECT REVIEW COMMENTS	**DATE:** 11 AUG 94	**PAGE** 1 **of** 1
TO: Army Corps of Engineers Sacramento District	**FROM:** (Section): EN-DM (Reviewer): Robert S. Woodruff	
PROJECT: Energy Report **LOCATION:** Yuma Proving Grounds, Arizona	**Year:** FY-94	**Line Item No.:**
Type of Action: Prefinal Submittal		

Item No.	Drawing No. Or Par. No.	COMMENTS	Review Action
1.	General	At several points in the report LPG is referred to as low pressure gas. This should be corrected to read Liquified Petroleum Gas. An example of this is on page 1-2.	
2.	General	The Table on page 1-3 shows an Item called Optimize Cooling Tower Control (Condensate Water Temperature). This should read (Condenser Water Temperature).	
3.	Page 1-3	The Lighting and Control ECOs item E has am SIR less than 1.0 but does not appear in table on Page 1-5.	
4.	Page 1-6	What is the age of the 55 Ton A/C Recip. Chiller in Building 451 ?	
5.	Page 4-2	Does Arizona Public Service have a demand charge ?	
6.	Page C-7	The conclusion to add a new small hot water boiler is well proven. The sizing of this new boiler should however be based on calculated loads not assumptions about "U" factors and the sizing of the original plant.	
7.	Page E-21	Is there any reason why the EER of this chiller is so low ?	

Post-It™ brand fax transmittal memo 7671	# of pages ▸ 2
To MR. NATHANIEL HUNTER	From R. C. LENNIG
Co. CESPK-ED-M	Co. KELLER & GANNON
Dept. INSTALLATION SUPPORT	Phone #
Fax # 916-557-7365	Fax #

KELLER & GANNON
Engineers & Architects
Quality Services Since 1941

25 July 1994

U.S. Army Engineer District, Sacramento
1325 J Street
Sacramento, CA 95814-2922

Attention: Mr. Nathaniel Hunter, Installation Support

Subject: Contract No. DACA05-C-92-0155
EEAP, Energy Survey of Boiler and Chiller Plants
Yuma Proving Ground, AZ

Reference: (a) Interim Submittal Review Comments from Using Facility (Jack Nixon)

Ladies and Gentlemen:

We offer the following responses to the using facility comments from Jack Nixon at Yuma Proving Ground (The responses are keyed to the comment numbers):

1. Done. Correction made.
2. Done. Correction made.
3. Done. Corrections are made.
4. Done. Correction made.
5. Done. An explanation is provided.
6. Done. Correction made.
7. Done. The "Block" text is corrected.
8. Done. The text is corrected to reflect the flow sheet which appears to be correct based on as built plans.
9. Done. This is the most current guidance provided by Sacramento District.
10. Done. The $25,000 maximum rebate limit is added to the subject paragraph.
11. Done. The paragraph is clarified. Option B4B, indeed, is less efficient.
12. Done. Statements will be coordinated.
13. Done. Statement will be corrected/clarified.
14. Done. Statement has been corrected.

\1640311\WORD\07-22.LT2
940722-1

1453 Mission Street, San Francisco, California 94103
Phone: (415) 621-1199 FAX: (415) 864-3681
Mail: P.O. Box 422430, San Francisco, CA 94142-2430

15. No changes are made: Based on MCWB temperatures, a 50 Degree F dew point is achieved only with an OA temp below 64 Deg. F when little cooling, if any, is required.

16. Done. The words will be changed as requested.

17. Done. The KWH savings is also expressed in MBTU's.

18. Done. The heading has been corrected.

19. Done. The tense of the paragraph will be corrected to reflect reality.

20. Done. Wording has been corrected.

21. Not done. The only economic options possible do not include costly long runs of dedicated fiber optic underground transmission lines to the remote buildings at YPG. Therefore, an FM-radio data transmission link is considered for the six buildings included in the survey.

22. PAX System preparation requirements are not included in current scope.

23. Not done. See item #21 response.

If you have any questions or require additional information , please do not hesitate to call.

Very truly yours,

Richard C. Lennig

Richard C. Lennig
Vice President

RCL:ab
16-403-11
Via Fax

FAC IMILE HEADER SHE_T

US Army Corps of Engineers
Sacramento District

US Army Engineer District, Sacramento
1325 J Street
Sacramento, California 95814-2922

May 9, 1994
(Date)

TO: Keller & Cannon 1453 Mission Street San Francisco, CA ATTN:	Fax Phone: 415-864-3681 Voice Phone: 415-621-1199
FROM: Nat Hunter CESPK-ED-M/ISS Corps of Engineers, Sacramento	Fax Phone: 916-557-7865 Voice Phone: 916-557-7413

Number of pages to follow: 5

Nathaniel Hunter
(Releaser's Signature)

COMMENTS: Mr. Nixon's Comments – In ARMS

DATE REC'D: 5-9-94
TIME REC'D: 11:30am
PROJECT No.: ______
ORIGINAL: ______ /FILE
COPY: ______

CESPK FORM 63
JAN 92

(Edition of 1 Jan 91 may be used)

29 APR 94 - 11:30:19 Page: 9
Project: QE102 - EEAP CHILLER STUDY at YUMA P.C
Review: INTERIM REVIEW

#	Reviewer	Location	Discipline

1 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 1<--YUMADEH<--HUNT

] PG 2-1, SEC 2.2, PARA 2: "COOING" SHOULD BE "COOLING".

2 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 2<--YUMADEH<--HUNT

] PG 2-1, SEC 2.2, SENTENCE 2: 2105 IS CITED TWICE FOR
] SURVEY.

3 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 3<--YUMADEH<--HUNT

] PG 2-2, SEC2.3.2, PARA 3: (1) SIR STANDS FOR SAVINGS TO
] INVESTMENT RATIO, VERSES SAVINGS TO INTEREST RATIO.

4 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 4<--YUMADEH<--HUNT

] PG 2-2, SEC 2.3.2, PARA 2: LINE 2, INSERT (ECO) PRIOR TO
] "IDENTIFIED".

5 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 5<--YUMADEH<--HUNT

] PG 2-3, SEC 2.3.3, PARA 3: WHY "4" TO 25 YEARS.

6 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 6<--YUMADEH<--HUNT

] PG 3-2, SEC 3.2.3, PARA 1: INSER WORD "RANGE" BEFORE WORD
] OPERATION CENTER.

Project: QE102 - EEAP CHILLER STUDY at YUMA P.G
Review: INTERIM REVIEW

#	Reviewer	Location	Discipline

===

7 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 7<--YUMADEH<--HUNT

] PG 3-6, UPPER LEFT CORNER 80 TON BLOCK, PRECEEDING PAGES
] INDICATE DERATING TO 45 TON, WHICH IT IS.

===

8 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 8<--YUMADEH<--HUNT

] PG 3.7: COMMENT ON COOLING TOWER QUANTITY, PARA 3.2.3 SAYS
] ALL CHILLERS ARE SERVED BY COMMON TOWER, BUT THIS SHOWS 4
] IN DIAGRAM IN THIS FLOW DIAGRAM; CORRECT FOR THE CHILLER.

===

9 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 9<--YUMADEH<--HUNT

] PG4-1, SEC 4.1.1: IT IS QUESTIONED WHETHER THIS IS THE
] MOST CURRENT ECIP GUIDANCE.

===

10 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 10<--YUMADEH<--HUNT

] PG 4.3, SEC 4.3, PARA 2: INSERT INFORMATION TO THE EFFECT
] THAT FOR APS LIGHTING REBATES, THE MAXIMUM IS $25,000.

===

11 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 11<--YUMADEH<--HUNT

] PG 4-4, PARA 5: QUESTION, IS B4B PROPOSING THAT THE
] EXISTING BOILER IS FOR HEATING. IF SO WOULDN'T IT MAKE THEM
] LESS EFFICIENCY.

29 APR 94 - 11:30:19 Page: 11
Project: QE102 - EEAP CHILLER STUDY at YUMA P.G
Review: INTERIM REVIEW

#	Reviewer	Location	Discipline

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12 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 12<--YUMADEH<--HUNT

] PG 4-4, PARA 6: THIS STATEMENT CONTRADICTS PAGE C-8 OR 4-10
] STATEMENT. WE QUESTION WHICH STEMENT IS CORRECT.

---

13 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 13<--YUMADEH<--HUNT

] PG 4-4, PARA 4: LINE 6 MAKES NO SENSE "THE WILL
] LIMIT----".

---

14 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 14<--YUMADEH<--HUNT

] PG 4-6, SEC 4.4.2, PARA 4, SENTENCE 8: CORRECT TO SAY,
] "THE ALLOCATION IS RARELY EXCEEDED AND NEVER MORE THAN ONCE
] ANNUALLY".

---

15 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 15<--YUMADEH<--HUNT

] PG 4-7, PARA 5: QUESTION, HOW EFFECTIVE WOULD THE
] EVAPORATIVE COOLERS BE WITH DEW POINT OF 50 DEGREES.

---

16 NIXON YUMA ENERGY
---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 16<--YUMADEH<--HUNT

] PG 4-8, SEC 4.4.3, PARA 3, LINE 2: SUBSTITUTE "LEFT ON" FOR
] WORDS "TURNED ON".

29 APR 94 - 11:30:19 Page: 12
Project: QE102 - EEAP CHILLER STUDY at YUMA P.G
Review: INTERIM REVIEW

#	Reviewer	Location	Discipline
17	NIXON	YUMA	ENERGY

---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 17<--YUMADEH<--HUNT

] PG 4-8, SEC 4.4.5, PARA 2: ALSO PROVIDE THE EQUIVALENT
] ENERGY SAVINGS OF THE 1,009,000KWH IN MBTU's.

#	Reviewer	Location	Discipline
18	NIXON	YUMA	ENERGY

---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 18<--YUMADEH<--HUNT

] PG 4-9, TABLE 4-1, HEADING "SIR ABOVE THAN 1.0" SHOULD BE
] "SIR MORE THAN 1.0".

#	Reviewer	Location	Discipline
19	NIXON	YUMA	ENERGY

---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 19<--YUMADEH<--HUNT

] PG 5-1, SEC 5: PARA 5, IS WRITTEN IN THE PAST TENSE AS IF
] WE HAVE ALREADY MADE SUCH A CONVERSION. WHY.

#	Reviewer	Location	Discipline
20	NIXON	YUMA	ENERGY

---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 20<--YUMADEH<--HUNT

] PG 5-2, SEC 5.1, PARA3, LINE 4: "REFRIGERANTS" SHOULD BE
] MADE SINGLAR PRIOR TO THE WORD BLENDS, ELIMINATING A DOUBLE
] PLURAL.

#	Reviewer	Location	Discipline
21	NIXON	YUMA	ENERGY

---- Yuma Proving Ground DEH (RV) COM: (602) 328-2933
---- Routing: 21<--YUMADEH<--HUNT

] PG 6-1, SEC6 6.2, PARA 3: THE RECOMMENDED EMCS STUDY MUST
] BE BASED UPON USE OF A DEDICATED FIBER OPTIC UNDERGROUND
] COMMUNICATIOS SYSTEM AS REQUIRED BY THE ARMY CORPS OF
] ENGINEERS HUNTSVILLE DIVISION. THIS FACT MUST BE ADDRESSED
] IN ANY RECOMMENDATION REGARDING EXPANSION OR REPLACING THE
] EXISTING EMCS.

Existing K0 system?

#	Reviewer	Location	Discipline
22	NIXON	YUMA	ENERGY
	---- Yuma Proving Ground DEH (RV)		COM: (602) 328-2933
	---- Routing: 22<--YUMADEH<--HUNT		

] APPENDIX A, 7.4 & 7.4.1: NEITHER OF THESE PARAGRAPHS SAY
] ANYTHIN ABOUT THE REQUIREMENTS FOR ADP ELECTRONIC (PAX
] SYSTEM) PREPARATION REQUIREMENTS FOR THESE TYPE PROJECTS,
] WHICH MUST BE ADDRESSED.

#	Reviewer	Location	Discipline
23	NIXON	YUMA	ENERGY
	---- Yuma Proving Ground DEH (RV)		COM: (602) 328-2933
	---- Routing: 23<--YUMADEH<--HUNT		

] VOLUMN 2
]
] APPENDIX I,PG 1-5: EMCS HARDWARE REQUIREMENTS MUST ADDRESS
] THE FACT THAT A DEDICATED OPTIC FIBER UNDERGROUND
] COMMUNICATIONS SYSTEM IS REQUIRED FOR ANY NEW ARMY EMCS,
] AND THE SYSTEM DESIGN MUST BE SUBMITTED FOR APPROVAL BY THE
] HUNTSVILLE EMCS DESIGN BOARD OF THE ARMY CORPS OF
] ENGINEERS.

Appendix B

Field Data Summary

BUILDING 451 (CACTUS CLUB)

Cooling is provided by an Air-Cooled Chiller:

Chiller

Location:	Outside, Rear Kitchen Entrance			
Manufacturer:	Carrier			
Model Number:	30GB-055-530AA			
Compressor 1	208/230 VAC	3 Phase	60 Hz	106.4/106.4 RLA 506 LRA
Compressor 2	208/230 VAC	3 Phase	60 Hz	106.4/106.4 RLA 506 LRA
Compressor 1	65 pounds R-22			
Compressor 2	71 pounds R-22			
Condenser Fans:	6 Each, 208/230 VAC, 1 Phase		60 Hz	4.6 FLA,0.43 HP 0.32 kW out

Chilled Water Circulation Pump

Location:	Mechanical Room
Manufacturer:	Bell & Gossett
Pump Model:	1-1/2AB 6-1/4BF
ID Number:	729783 CR
Operating Characteristics:	77 GPM, 33 Ft TDH, 1.5 HP, 1750 RPM
Pump Motor:	1725 RPM 3 Phase 60 Hz 200-208 VAC 6.0 A 12 SF, Class B, Des B, Code K, Frame 1.46 JM
ID Number:	478043 CR
Load Measurement:	208 VAC (measured) 4.4, 4.4, 4.6 Amps per leg
Note:	Chilled water distribution piping is copper, thus, the ultrasonic flow meter could not be used. Chilled water flow must be determined based on pump operating characteristics.

BUILDING 506 (EM BARRACKS)

Building 506 consists of two three-floor dormitory wings, long axes at right angle to each other, with a dining facility at the point of intersection. The dining facility has been closed with no plans to reopen it in the future. (All equipment is still in place, but the dining areas are now used for administrative purposes.)

Steam boilers (2 each) generate steam which is converted to hot water for heating system use. Hot water distributed to air handing units in both wings.

Domestic hot water (DHW) is generated in two tanks located in the mechanical room. Steam from the boilers passes through heat exchangers in the tanks. The DHW is recirculated throughout both wings.

Space cooling is provided by a combination of a 220 Ton water cooled centrifugal chiller located in the mechanical room and an Ice-On-Coil thermal storage system. The Ice-On-Coil system utilizes an 80 Ton (before derating to about 36 tons as a glycol chiller to produce ice) to chill a mixture of ethylene glycol which is circulated through the Ice Storage Tank. Water in the tank freezes onto the coils for later recovery to provide cooling during peak electrical demand periods.

The 220 ton chiller is operated from about 1530 in the afternoons until about 1000 the next morning. Cooling during peak electrical demand periods is provided by the ice storage system. Refer to the attached flow diagrams.

220 Ton Water Cooled Chiller

Location: Boiler Room

Manufacturer: Trane Centrifugal Chiller
Model Number: CVHE-020F-AL-2GB2451DEZA11DEZA000 0000052 ZOAO

Serial Number: L87J04327

	Qty	VAC	Hz	Phase	RLA	Max LRA Y	Max LRA Delta
Compressor Motor	1	460	60	3	211	426	1305
Oil Pump Motor	1	115	60	1	4.9 FLA		
Oil Tank Heater	1	115	60	1	1000 Watts		
Control Circuit	1	115	60	1	60 VA Max		
Purge Compr Motor	1	115	60	1	5.0 FLA		

Refrigerant: 450 Pounds R-11

Condenser Water Circulation Pump

Location: Boiler Room

Manufacturer: PACO
Model Number: 04-40957-030061A09-2 AX-C01703

Design: 630 GPM 55 Ft TDH 8.6 HP

Motor: 15 HP 1765 RPM 208-230/460 VAC 60 Hz 3 Phase 86.5% Eff
42.6-38.6/19.3 Amps

Flow Measurement: Ultrasonic Flow Meter, Pipe 18.5-inch outside circumference (5.89-inch OD = 5-inch Dia); adjusted flow measurement: 610 GPM measured

Chilled Water Circulation Pump

Location:	Boiler Room
Manufacturer:	Fredrick (nameplate obscured)
Model Number:	35102-76 Size 4G
Motor:	General Electric
Motor Model:	NEK9A76B11 5K184BD205A
Motor:	5 HP 1750 RPM 200-230/460 VAC 13.4/6.7 Amps 84.0% Eff
Flow Measurement:	Ultrasonic Flow Meter: 203.4 GPM through 5-inch Diameter Schedule 40 PVC Pipe

Cooling Tower (for 220 Ton Chiller)

Location:	Outside
Manufacturer:	Baltimore Air Coil
Model Number:	3FT-24160
Serial Number:	83-6915A
Field Observation:	Blowdown valve is cracked open, continuously allowing water to drain (provided to maintain proper water chemistry). Plastic packing is deteriorating and falling into the sump; poor distribution of cooling water noted - most of flow is concentrated at one end of the tower.
Recommendations:	Repair/replace packing. Add automatic blowdown controls or alternative water treatments.

Primary Chilled Water Circulation Pump

Location:	West Wing Mechanical Room
Manufacturer:	PACO
Model Number:	Smart Pump 11-30955-133201 TC88D0520401
Pump Data:	350 GPM 75 Ft TDH 9.4-inch Impeller Diameter
Motor:	PACO Induction Motor
Motor Data:	10 HP 230/460 VAC, 27.0/13.5 FLA, 3 Phase 1745 RPM 1.15 SF
Motor Serial Number:	871511034

West Wing Chilled Water Circulation Pump

Location:	West Wing Mechanical Room
Manufacturer:	Bell & Gossett
Model Number:	(casting only; no pump name plate) P42190; no data on impeller
Motor:	Century 6-350327-45
Motor Data:	5 HP 1745 RPM 200-230/460 VAC 15.4-14.7/7.2 FLA

Ice-On-Coil System Ice Water Circulation Pump "HE"

Location:	Outside
Manufacturer:	PACO Smart Pump
Model Number:	11-40127-1A6201
Serial Number:	TL88D0520501
Pump Data:	500 GPM 35 Ft TDH 9.80-inch Impeller Diameter 1165 RPM
Motor:	U.S. Electric Motors, Unimount 125 High Eff Frame 254T
ID Number:	A917/R022351R031F
Motor Data:	7.5 HP 1165 RPM NEMA B 87.5% Eff 208 VAC 22.2 Amps measured 230/460 VAC 20.2/10.1 FLA 25.2/12.6 SFA

Ice-On-Coil System Glycol Circulation Pump

Location:	Outside
Manufacturer:	PACO Smart Pump
Model Number:	11-25123-133201
Serial Number:	TC88D052060
Pump Data:	280 GPM 90 Ft TDH 10.5-inch Impeller Diameter 1165 RPM
Motor ID:	A933/R02P356R014F
Motor Data:	15 HP 3 Phase 1765 RPM NEMA B 89.5% Eff 208 VAC 43.3 Amps measured 230/460 VAC 39.2/19.6 FLA 48.6/24.6 SFA
Pipe Size:	4-inch Diameter, ID 4.026-inches, Schedule 40, Operating Pressure 18 psig
Flow Measurement:	Ultrasonic Flow Meter set at 4.026-inch ID = 356.5 GPM on 28 Oct 93 1715

Ice-On-Coil System Temperature Sensors (Refer to attached flow diagram)

Manufacturer: Omega

Type: T Type Thermocouples

Points Connected: TE-1, 2, 3, 4, 5 & 6

Ice-On-Coil System Flow Meter (Refer to attached flow diagram)

Manufacturer: Yokagawa (Georgia, USA)

Model Number: Vortex Type YF110-ALPA1A-5363 C/FMF

Meter Data: 24 VDC Power Supply, Pulse Output, K Factor 5.323 P/Gal

Fitting Number: SCS14 Star 70

Steam Boilers (2 Total)

Location: Boiler Room

Manufacturer: Cyclotherm

Model Number: Type 4400B-A3-23

Boiler Data: Max WP 125 psig Heating Surface 380 SF 4315 Pounds/Hr Stean
Built 1958 Plate 3/8-inch Heads 9/16-inch

Serial Number: 11067; National Board Numbers 7558 & 7559

Burner: Gun Type Dual Fuel (LPG and No. 2 Fuel Oil)
nameplate data painted over, removed, could not find

Controls: Boiler Control System replaced during field data collection period. New control package has capability of accepting add-on communications package, auto-dial features, etc. Twenty to thirty-six points available for monitoring/control from remote location. Blowdown is manual.

Boiler Efficiency: Combustion efficiency measured using a hand-held oxygen analyzer (C5A) and high-temperature bi-metallic thermometer & confirmed with a permanently installed thermometer on boiler exhaust breaching.

Boiler Number 1: Firing Efficiency Tested 2 November 1993 at 1500
Average of 10 readings = 680°F, 12.4% O_2 = 65% Eff

Boiler Number 2: Firing Efficiency Tested 4 November 1993 at 1400
Average of 5 readings = 440°F, 12.2% O_2 = 73% Eff

General: Equipment is old, but has been maintained in good condition, water treatment is practiced and tested periodically. Possible energy conservation measures include installation of turbulators in fire tubes and replacement of existing burners with the addition of oxygen trim combustion controls.

Domestic Hot Water Generators

Location:	Boiler Room
Tank:	2 Each, 3'-6" Diameter, 8'-0" Long (~575 Gallons); 2" thick fiberglass insulation (new)
Heat Source:	Steam coils; 2-way valves controlled by acquastat on tank(s)

DHW Circulation Pump

Location:	Boiler Room
Manufacturer:	Bell & Gossett
Model Number:	106197, Series 1000 BNFI D19

Condensate Return System / Boiler Feed Pumps

Location:	Boiler Room
Pump Data:	2 Each, nameplates not found; missing or painted over
Motor Manufacturer:	Electro-Dynamic
Motor Data:	Frame 213, 5 HP, 208/230-440 VAC, 3 Phase, 13.9/12.8-6.4 Amps, 3490 RPM

BUILDING 2105 RANGE OPERATIONS CENTER

Building 2105 is the main operations center for Yuma Proving Ground. The North side of the building has two floors; the South side has a single story. Most of the building houses administrative offices. A computer center and several other technical areas are also housed in the building.

HVAC is provided by air handling units which utilize chilled and hot water to provide space conditioning. Mechanical systems are fairly unique. Chilled water is provided by a combination of mechanical chillers and an absorption chiller. Hot water is provided by existing boilers and by solar collectors. The solar collectors are of the parabolic tracking type. Hot water generated by the solar collector field is used in the absorption chillers, reducing electric demand that would be created by use of mechanical cooling systems. The solar heating installation was one of eleven such demonstration type installations placed at Army facilities, and is, reportedly, the only system still operating.

Chiller Number C-1 125 Ton, Water-Cooled Centrifugal Chiller

Location: Mechanical Room

Manufacturer: Trane, Centravac

Model Number: CVHA-011C-HA-06BC1H1AC15H1A521

Serial Number: L78E12717

Motor Number: 70550426-00

Evaporator: 2-Pass

Condenser: 2-Pass

Electrical: Rated Voltage: 460 VAC, 60 Hx, 3 Phase
Utilization Voltage: 414-506 VAC
Minimum Circuit Ampacity: 171 Amps
Maximum Fuse: 300 Amps
Recommended Dual Element Fuse: 203 Amps

Component	Qty	VAC	Hz	Phase	RLA	LRA	Delta	LRA-Y
Compressor Motor	1	460	60	3	130	722	0	230.0
Oil Pump Motor	1	460	60	3	0.6			
Oil Tank Heater	1	115	60	1	750 Watts			
Control Circuit	1	115	60	1	60 VA Max			
Purge Compressor Motor	1	115	60	1	5.8 FLA			

Refrigerant: Field Charged 415 pounds R-113

Max Air Pressure: Supply 20 psig

Design Pressure: Hi Side 15 psig, Lo Side 15 psig

Factory Test Pressure: Hi Side 45 psig, Lo Side 45 psig

Chiller Number C-2 40 Ton, Water-Cooled Reciprocating Chiller

Location: Mechanical Room

Manufacturer: Trane

Model Number: CGWA0404RB51CC5C4B361BE

Serial Number: 178D12595

Electrical: Rated Voltage: 466 VAC, 60 Hx, 3 Phase
Utilization Voltage: 414-506 VAC
Normal Service Voltage: 440-460-480 VAC

Component	Qty	VAC	Hz	Phase	RLA	LRA
Compressor Motor	1	460	60	3	59	315

Refrigerant: Factory Charged: Circuit 1 55 pounds R-22
Evaporator 1: 286 CDS 1 262

Test Pressure: Hi Side 450 psig, Lo Side 300 psig

Max Overcurrent: 125 Amps

Main Circuit: 74 Amps

Continuous Circuit: 15 Amps, Ampacity 2

Compressor Model: CRHR400C-3GAT

Compressor Serial No.: 17029A85B1

Field Measurement: CWS Flow = 7.529 FPS, 3-inch Diameter Pipe (9-1/4-inch Circumference) Iron Pipe Schedule 40 = 173 GPM; for check only (pump on for check, chiller not energized)

Chiller Number C-4 165 Ton, Absorption Chiller - Not included in Study

Location: Mechanical Room

Manufacturer: Trane

Chiller Number C-5 125 Ton, Water-Cooled Hermetic Centrifugal Chiller

Location: Mechanical Room

Manufacturer: Carrier

Model Number: 19DK4629AE

Serial Number: 630233787

Refrigerant: R-11

Component	Size	Serial Number
Compressor	19DH11	37473
Unishell	19DX157	40476

Component	Qty	VAC	Hz	Phase	RLA	RLA	LPAmp
Compressor Motor	1	460	60	3	184	184	7333

OLT Amp: 199 LP Amp: D1042

Test Pressure:	30 psig, 205 kPa
Design Pressure:	15 psig, 101 kPa
Evaporator Wtr Pressure:	150 psig, 1034 kPa
Condenser Wtr Pressure:	150 psig, 1034 kPa
Field Measurement:	CHWS Flow = 4.549 FPS & 5.450 FPS, 6-inch Dia PVC Pipe = 403 GPM & 246 GPM CWS Flow = 7.582 FPS (Avg), 8-inch Gruvlock Pipe (Schedule 40 Steel) = 1,182 GPM

Chilled Water Circulation Pump P-4 (for Chiller C-1)

Location:	Mechanical Room
Pump Manufacturer:	Aurora Pump
Pump Model:	NA, 300 GPM, 60 Ft TDH (@ Equipment Schedule)
Suction Pressure:	25 psig
Discharge Pressure:	44 psig
Pump Motor:	Gould Century, Model 6-330771-02 FR S213T Type SC
Motor Data:	7.5 HP, Code H, 60 Hz, 3 Phase, 1750 RPM, 277/460 VAC, 21/10.5 Amps

Condenser Water Circulation Pump P-5 (for Chiller C-2)

Location:	Mechanical Room
Pump Manufacturer:	Aurora Pump
Pump Model:	84-17177 Type 344A-BF, Size 2 x 2.5 x 9
Pump Data:	120 GPM, 54 Ft TDH, 1750 RPM, Pressure 24 psig
Pump Motor:	GE Motor, Model 5KW18AD205A HP 5 No UCK8A038-B11
Motor Data:	1730 RPM, 60 Hz, 1.15 SF, PBMA BRGS, 200-230/460 VAC, 13.6/6.8 Amps 3 Phase, Tonf Cont Drive End 30BC02XP3, Code S Ins B Opp End 30BC0XP3, Max KVAR 2.5 Design, B Enclosure, DP NEMA, Nom Eff 85.8%, Frame 184T Type, Guar Eff 82.5%

Condenser Water Circulation Pump P-6 (for Chiller C-1)

Location:	Mechanical Room
Pump Manufacturer:	Aurora Pump
Pump Model:	84-15260 Type 344A-BF, Size 3 x 4 x 9B
Pump Data:	360 GPM, 40 Ft TDH, 10 Ft NPSH, 1750 RPM, Pressure 16 psig

Pump Motor: Gould Century, Part 6-330771-02, Frame S213T, Type SG

Motor Data: 7.5 HP, 1750 RPM, 60 Hz, 3 Phase, Code H, 230/460 VAC, 21/10.5 Amps, Continuous, Ambient 40°C, 1.15 SF, Insulation Class B, Code DESC B, Serial Code U3, Frame End 307 Off 208

Condenser Water Circulation Pump P-7 (for Chiller C-5)

Location: Mechanical Room

Pump Manufacturer: Bell & Gosset 1531

Pump Model: E-10-V8BF, Serial Number: 1087444 KZ

Pump Data: 105 GPM, 25 HP, 1750 RPM, Pressure 28 psig
Note: larger capacity than shown on equipment schedule

Pump Motor: U.S. Electric Motors

Motor Data: 25 HP, 1760 RPM, 60 Hz, 3 Phase, Insulation Class B, Frame 284JP/DP, 460 VAC, 31.5 Amp, Design B, Code G, 1.15 SF, Continuous Rating 40°C Ambient, Lower Shaft End Bearing 6312-J, Upper or Operating End 6210-2Z-J, ID Number: R-9366-03-518S, NEMA Nominal Efficiency: 37.5 %

Chilled Water Circulation Pump P-11 (for Chiller C-2)

Location: Mechanical Room

Pump Manufacturer: NA

Pump Model: NA

Suction Pressure: 28 psig

Discharge Pressure: 44 psig

Pump Motor: Marathon Electric, Model PVK 145TTDR706DC

Motor Data: 2 HP, 1735 RPM, 3 Phase, 60 Hz, 208-230/460 VAC, 6.0/3.0 FLA, Corr 4.7/2.5 Amp, Type TDP, Code J, Insulation Class B, 1.15 SF, AVAR 1.2, Frame 145T, Shaft End Bearing 205, Opr End Bearing 203

Chilled Water Circulation Pump P-12 (for Chiller C-4)

Location: Mechanical Room

Pump Manufacturer: Aurora Pump

Pump Model: NA

Suction Pressure: 30 psig

Discharge Pressure: 30 psig (not operating at time of inspection)

Pump Motor:	Gould Century, Model PVM213TT0R7026GDL
Motor Data:	7.5 HP, 1750 RPM, Type TDR, Frame 213T, Design B, Code H, Insulation Class B, Enclosure DP, 3 Phase, 60 Hz, 208-230/460 VAC, 21.6/10.8 Amps, SF 24.4/12.2 Amps, Corr 15.8/7.9 Amps, 1.15 SF, Nom PF 76.6, Max KVAR Cap 5.3, Duty Continuous, Max 40°C, Shaft End Bearing 307, Opp End Bearing 206, M125, NEMA Norm Eff 84.0%

Condenser Water Circulation Pump P-17 (for Chiller C-4)

Location:	Mechanical Room
Pump Manufacturer:	Aurora Pump
Pump Model:	84E8246-1, Type 411A-PF, Size 4 x 5 x 11A
Pump Data:	700 GPM, 66 Ft TDH, 1750 RPM
Pump Motor:	Marathon Electric, Model Number PJ 256TTDR70 26 GN W, Frame 256T, Type TDR, Design B, Code G, Insulation Class B, Enclosure DP
Motor Data:	20 HP, 3 Phase, 60 Hz, 1755 RPM, 230/460 VAC, 51.0/25.5 Amps, Corr 43.2/21.5 Amps, 1.15 SF, NEMA Nominal Eff 87.5%, Nominal PF 84.0, Max KVAR Cap 8.0, H128, Continuous Duty, Max Ambient 40°C, Shaft End Bearing 309, Opp End Bearing 205, SN 01-91759-8/3-16

Cooling Towers

Location:	Outside
Manufacturer:	Baltimore Air Coil
Model Number:	FXT-266K (3 each)
Serial Number:	2-2BX144 (for one of 3)

BUILDING 3482 TEST PREPARATION FACILITY

Building 3482 is heated and cooled using a 6-zone air handling unit. Cooling is provided by a water cooled DX cooling unit. Continuous measurements were taken of the condenser water flow, compressor power consumption and air temperatures up and downstream of the cooling coil. The constant volume air flow was measured in the supply ductwork of each of the 6 HVAC zones downstream of the cooling coil.

Air Handling Unit: Carrier CA 135, Form 39C-1P dated 1966

Model Number: 39CA134, 26,620 CFM, Delta SP 1.005, Total 1.47-inches H_2O, Fan 400 RPM, 9.5 BHP, 15 HP Motor, 1750 RPM 460 VAC, 3 Phase, 60 Hz

SA Fan Motor: Marathon 9K254TT0R7026BDW, 15 HP, 1735 RPM, 60 Hz, 3 Phase, Serial Number 916732, 230/460 VAC, 40/20 FLA, Frame 254T Type TDR-BE, Design B, Code F

Cooling Coil: 51.6 FA, 4 Rows, 8 Fins per Inch, Aluminum, 75.1°F EDB, 60.8°F EWB; 55.1°F LDB, 51.2°F LWB

Condensing Unit

Manufacturer: Carrier

Model Number: 07LB081

Unit Data @ Catalog: Refrigeration Effect = 73.5 Tons, Sat Suct. Temp. = 35°F, Sat Dischg. Temp. = 105°F, EWT = 85°F, LWT = 95°F, 90.8 Ton Heat Rejection to Condensate @ 220 GPM, 460 VAC, 3 Phase, 60 Hz, 60.6 Design kW, 70.0 Max kW, Water Delta P = 12.8 Ft; R-22 Cond Temp 105°F, Fouling Factor 0.0005, 3 Passes @ 07L-202-3 @ 7-2-71

Chiller Test Data: 07LB081-A269; SN KL60551; Design 480 VAC, 3 Phase; Actual 460 VAC, 3 Phase; Design 72 FLA, Rated 62 Tons at 35°F Suction & 105°F Condensing Temperatures (73.5 Tons @ Mnfr); Chiller Design CWS 220 GPM, Actual 230 GPM

Compressor: Nameplate data: Carlyle Compressor Company, Model OSCH113500, Serial Number 4237PA0714, Motor 06L 3420603,

460 VAC, 3 Phase, 60 Hz, 427 LRA, 1800 Syn RPM, Design 450/2105 psi/kPaLS HS Test 245/11691 psi/kPa

Condenser: Carrier Model 09RL084119 Serial Number 9900698, National Board Number 108694, Built 1971, Max allowable working pressure 385 psi at 300°F, Shell 0.3125 Thick

Cooling Tower: Frigid Coyle, Model 5900 YCT-5-100 S/O 31710, Serial Number 29917, 10 HP Motor, 460 VAC, 1750 RPM, 12.5 Amp, R-22

CT Blower Motor: Century Electric Motor R309 Part 57722-01, Frame S215T, 10 HP, 1750 RPM, 3 Phase, 60 Hz, 460 VAC, 12.5 FLA, 85.6% Eff, 87.5% PF, 1.15 SF

Balancing Report 6/30/72: 26,235 CFM Total at 1750 RPM Motor, 460 VAC, 3 Phase, 60 Hx, 470 RPM Fan

Zone Air Flow Measurements:

Zone Width	Zone Length	Avg FPM	No. Measurements	CFM (Calc)
16-inch	48-inch	902	10	4,810
16-inch	48-inch	875	10	4,667
24-inch	48-inch	788,792	8,10	6,320
24-inch	48-inch	1075,1082	8, 8	8,628
16-inch	48-inch	962	8	5,131
16-inch	48-inch	725	8	3,867
Total				33,423

BUILDING 3490 WEAPONS EVALUATION FACILITY

The Weapons Evaluation Facility is a multiple use building. The large central High-Bay area of the building is devoted to vehicle maintenance. The North side is a gun (cannon) shop where non destructive testing is conducted, and the South side of the building houses administrative and shop offices. Three chillers serve the building. Chiller No. 1 serves the south side offices; Chiller Nos. 2 and 3 serve the gun shop and its storage rooms on the North side of the building. All chillers are air cooled and provide chilled water to air handling units. Air Handling units served by Chiller Nos. 2 and 3 are pad-mounted, located outside near the chillers. The air handlers served by Chiller No. 1 are located in ceiling spaces above office areas served.

Chiller No. 1 - 25 Ton Air Cooled Chiller

Location:	Building South Side - Outside
Manufacturer:	Webster
Model Number:	CPK26A-22-3 (from records, unit has no accessible nameplate)
CHW Circ. Pump:	Fluid Pumps Inc. Model 3567135A(4?), Serial No. 1732917, Manufactured 9/87, Measured Load: 460 VAC, 1.4 Amp per leg (3 legs), Suction 19.0 psig, Discharge 43.0 psig, Piping is Copper: ultrasonic flow meter cannot be used.
Circ Pump Motor:	Bell & Gosset Motor, 1.5 HP, 3 Phase, 60 Hz, 200-208 VAC, 6.0 FLA

Chiller No. 2 - 50 Ton Air Cooled Chiller

Location:	Building North Side - Outside
Manufacturer:	Webster
Model Number:	CPK51A2 (from records, unit has no accessible nameplate), SN 572L07928
Compressor (2 Each):	Copelamatic 4RH2-2500-TSK, 460 VAC, 3 Ph, 60 Hz, 45 FLA, 214 LRA
Condenser:	Bell & Gosset, Prod. No. 0-43104, Cat No. REPA106, (R10, R E11 ?)
CHW Circ. Pump:	PACO Pump 11-159551332011622, Impeller DJM20943, 81.6 GPM 57.9 Ft TDH,
CHW Pump Motor:	GE 5K182AD210A, 3 HP, No. VEK0A062B09, 1745 RPM, 200-230/460 VAC, 3 Phase, 60 Hz, 8.6/4.3 FLA, 1.7 Max KVAR, 84.0% Eff, Measured Load: 460 VAC, (2.7 A, 2.9 A, 2.9 A)

Chiller No. 3 - 100 Ton Air Cooled Chiller

Location:	Building North Side - Outside
Manufacturer:	Webster
Model Number:	CPK100A2T (from records, unit has no accessible nameplate)
Compressor:	Copelamatic, 4RH1-2500-TSR, 480 VAC, 3 Phase, 60 Hz, 45 FLA, 214 LRA, Serial No. S7009614

CHW Circ. Pump:	PACO Pump 11-20 51-1332011 EJM20945, 149 GPM 45 psig, Suction 19 psig, Discharge 37 psig, Piping is Copper: ultrasonic flow meter cannot be used.
CHW Pump Motor:	Nameplate burned off by Sun; Load Measurement: 460 VAC, (4.2, 4.3, 4.2 Amps)

BUILDING 3510 CONSTANT TEMPERATURE AMMUNITION (STORAGE) BUILDING

Building 3510 is a 3-Cell storage magazine. Each cell has its own built-up air handling unit complete with heating and cooling coils. Cooling is provided by a water cooled DX unit. Refrigerant is piped to DX coils on each of the three AHU's. Since all refrigerant piping is copper, Ultrasonic Flow Meters cannot be used. Condenser water flow was measured using an Ultrasonic Flow Meter. Air flow from each AHU was also measured. A heat balance can be performed using recorded CWS & CWR, SA & RA (from each unit) temperatures and the condenser water and air flow data.

DX Cooling Unit - Condenser Heat Exchanger

Location:	Mechanical Room
Manufacturer:	Trane
Model Number:	National Board 178638, Serial Number 175697
Unit Data:	Max W.P. 300 psi at 300°F, BHuild 1982, CDS 321, Shell Thickness 0.250-inches, TS Thickness 0.812-inches, Head R. Flat, Shell Side Only A.S.M.E., CPN E2459.5

DX Cooling Unit - Compressor

Location:	Mechanical Room
Manufacturer:	Trane
Model Number:	RWUA0481EB51FC5C4L361BEJ, Serial Number L82E03959
Compressor Motor:	1 Each, 3 Phase, 60 Hz, 3.75 LRA, Maz Over Current Device Ckt 1 150, Cont Ckt 15, Min Ckt 1 Ampacity 88, Rated Voltage 460 VAC, Utilization Voltage 414-506 VAC, Nominal System Voltages 440-460-480 VAC, Fiel Charge 12 CDS 321, Test Pressure High 425 psig, Low 300 psig
Compressor:	Model 1E5J68N, Serial No. 2G06A950, 3 Phase, 60 Hz, Regrigerant 12

Rated Voltage	FL WC	Current AC	LR Current	Utilization Range
200	147	171	652	187-220
230	133	155	750	207-283
460	67	78	375	414-506

Cooling Tower

Location:	Roof above mechanical room
Manufacturer:	Marley
Model Number:	Nameplate painted over - could not read
Fan Motor:	Gould 6-322464-02, Frame S182T, Type SC, 3 HP, Code J, 60 Hz, 3 Phase, 1745 RPM, 230/460 VAC, Continuous 40 Amps, 1.155 SF, InsulationClass B, MEMA B, Form MCA S Code 21 20, 76.9% Eff, Manual Blowdown control

AHU-A Supply Fan & Motor

Location: Mechanical Room

Fan Manufacturer: Chicago Axial Centrifugal Heavy Duty Fan

Fan Model Number: Tag No. SF-2, Serial No. 78364-M

Fan Data: Size 135ABG

Motor Manufacturer: Westinghouse Life Line Motor

Motor Data: 3 HP, 3 Phase, 60 Hz, 24 Hour Rating, Frame 4, 40°C Rise, 440 VAC, 1/2 HP @ 875 RPM & 1.2 Amp/Line; 2 HP @ 1750 RPM & 2.8 Amp/Line, Locked KVA Code J, S# 12N834, SFR 13N8342, SF 1.25 @ 1 HP and below, SF 1.20 @ 1.5 HP to 2 HP, 1.15 SF @ 3 HP and above

Air Flow Measurement: Size = 28-inch x 20-inch; 3 traverses with annemometer: 283 FPM @ 8 readings, 309 FPM @ 8 readings, 325 FPM @ 8 readings.

AHU-B Supply Fan & Motor

Location: Mechanical Room

Fan Manufacturer: Westinghouse Centrifugal All Purpose Fan

Fan Model Number: BRL Amp 30BC02XP 25 BC02XP

Fan Data: Size 8015, Style PXY 1002, Shaft Eng 1

Motor Manufacturer: General Electric

Motor Data: 5K182AL9028 KNF, 3 HP to 0.75 HP, 460 VAC, 3 Phase, 60 Hz, 4.3 - 1.7 Amp, 1750 - 865 RPM, Temp. Rating Continuous, 40°C Max Ambient, Frame 182T Type K, Insulation Class B Code L, 1.15 SF

Air Flow Measurement: Size = 28-inch x 20-inch; 3 traverses with annemometer: 493 FPM @ 8 readings, 489 FPM @ 7 readings, 402 FPM @ 6 readings.

AHU-C Supply Fan & Motor

Location: Mechanical Room

Fan Manufacturer: Chicago Axial Centrifugal Heavy Duty Fan

Fan Model Number: NA, Same as AHU-A

Fan Data: Size 135ABG

Motor Manufacturer: Westinghouse Life Line Motor, Same as AHU-A

Motor Data: 3 HP, 3 Phase, 60 Hz, 24 Hour Rating, Frame 4, 40°C Rise, 440 VAC, 1/2 HP @ 875 RPM & 1.2 Amp/Line; 2 HP @ 1750 RPM & 2.8 Amp/Line, Locked KVA Code J, S# 12N834, SFR 13N8342, SF 1.25 @ 1 HP and below, SF 1.20 @ 1.5 HP to 2 HP, 1.15 SF @ 3 HP and above

Air Flow Measurement: Size = 28-inch x 20-inch; 3 traverses with annemometer: 150 FPM @ 8 readings, 359 FPM @ 8 readings, 402 FPM @ 8 readings.

Condenser Water "Cooling Coils" Circulation Pump (PU-4)

Location: Mechanical Room

Manufacturer: Franklin Electric, Pump has no name plate, data is for motor only

Model Number: 1303032116

Motor Data: 1 HP, 3 Phase, 60/50 Hz, 3450/2870 RPM, Insulation Class B, SF 1.4/1.0, Frame 56U, KVA Code L, Max Amb 40°C, 208-230/460 VAC, 3.2-3.2/1.6 FLA, 4.2-4.2/2.1 SFA, Cat E48787, Time Rating DP, CO 6873, V38/415HZ50A1.2/2.0

Condenser Water "Condensing Unit" Circulation Pump (PU-5)

Location: Mechanical Room

Manufacturer: Magnetek M Century Motor, Pump has no name plate, data is for motor only

Model Number: E-Plus Pump Motor, Part S-36043001

Motor Data: 2.0 HP, 1.5 kW, Frame N145JM Type SC, Code M, 3 Phase, 60 Hz, 1745 RPM, Rating Continuous, Amb 40°C, Form KHC, Serial Code BK10, Insulation Class B, 230/460 VAC, 6.4/3.2 FLA, 7.2/3.6 SFA, Cat No E174, MEMA Nom Eff 81.5%, 73% PF, ONEC DP

Air Washer "Spray" Pump (PU-1,2 & 3)

Location: Mechanical Room

Manufacturer: Franklin Electric, Pump has no name plate, data is for motor only

Model Number: 1303042110

Motor Data: 1.5 HP, 3 Phase, 60 Hz, 3450/2870 RPM, Insulation Class B, 1.3/1.0 SF, 208-230/460 VAC, 4.5-4.8/2.4 FLA, 5.5-5.8/2.9 SFA, Frame 56J, KVA Code M, Max Amb 40°C, Date Code G89

Appendix C

Boiler Efficiency Improvement Project Calculations

APPENDIX C

Table of Contents

Summary of Building 506 Boiler Efficiency Improvement Projects

ECO No.	Description	Saved (Mil BTU/Yr) Distillate	LPG	Energy Cost Saved $/Year	LCC $	O&M Cost Saved $/Year	LCC $	Invest-ment $	Economic Measures SIR	Payback	AIRR
B1	New Burners & O2 Trim	330	346	$6,923	$87,045	($1,320)	($14,177)	$62,241	1.17	11.1	5.6%
B2	Engineered Turbulators	164	163	$3,371	$42,346	($519)	($5,574)	$2,186	16.82	0.8	26.1%
B3	Auto-Blowdown w/ Heat Recovery	2.51	2.21	$49.61	$622	$6,798	$73,011	$16,302	4.52	2.4	15.6%
Totals for B1, B2 & B3		**497**	**511**	**$10,344**	**$130,013**	**$4,959**	**$53,260**	**$80,728**	**2.27**	**5.28**	**10.4%**
B4A	**Modular Boilers - Heating & DHW**	**466**	**578**	**$10,435**	**$131,662**	**$17,820**	**$191,387**	**$122,560**	**2.64**	**4.3**	**11.5%**
B4B	Modular Boilers for DHW Only	200	247	$4,467	$56,354	($1,980)	($21,265)	$73,923	0.47	29.7	-0.6%

Recommendation: Each of the above project groupings are mutually exclusive, e.g., Project B4A cannont be economically justified if the group of B1, B2 & B3 are implemented.

Project B4A is recommended for implementation due to its superior economics

Building 506 Boiler Efficiency Improvements

System Operating Efficiency (See attached Methodology)

	Boiler 1	Boiler 2	
Firing (Combustion) Efficiency Test	65.0%	73.0%	Firing No. 2 Fuel Oil
Auxiliary Equipment Uses	-1.0%	-1.0%	
(Not significant; allowance only)			
Radiation Losses @ Figure D-1	-4.0%	-4.0%	
Blowdown Losses (Manual BD)	-2.0%	-2.0%	
Leaks (None found, allow)	-0.5%	-0.5%	
Conduction/Convection	-2.0%	-2.0%	
(Boiler Room only, not including distribuyion piping in building; system in "fair" condition.)			
Shut-Down/Cycling Losses	-3.0%	-3.0%	
(Much oversized for current use)			
General Equipment Condition	-2.0%	-2.0%	
(Systems in "fair" condition)			
Overall Plant Efficiency	**50.5%**	**58.5%**	
Average for No. 2 Fuel Oil Use	**54.5%**		

Best available dual fired burners provide about 80% firing efficiency for No. 2 Fuel Oil and about 75% when firing gas. Assume these burners also have the same 8% firing efficiency difference.

Average for LPG Fuel Use **46.5%**

Historical Fuel Consumption

	LPG (Gal)	No. 2 FO (Gal)
Oct 92	0	1,202
Nov 92	0	0
Dec 92	13,500	2,400
Jan 93	0	2,057
Feb 93	0	1,203
Mar 93	0	1,200
Apr 93	0	0
May 93	0	0
Jun 93	0	1,226
Jul 93	0	1,230
Aug 93	2,250	1,125
Sep 93	0	0
Totals	15,750	11,643
Heating Value (BTU/Gal)	95,000	138,700
Cost ($/Gal)	$0.70	$1.83778

Note: No. 2 FO cost includes YPG costs for distribution and capitalization of equipment for fuel receiving and dispensing. (RATE A COSTS)

	LPG	Total	No. 2 FO	
Energy Use in FY93 (Mil BTU)	**1,496**		**1,615**	
Total		**3,111**		
Cost per Million BTU's	**$7.37**		**$13.25**	
Existing Plant Efficiencies	**46.5%**		**54.5%**	
Average FY93 System Load	**696**		**880**	**Million BTU/Yr**
Total FY93 System Load		**1,576**		**Million BTU/Yr**

Replace existing burners with high efficiency burners including oxygen trim controls.

Existing boilers are in adequate condition. Maintenance and operation are good, however, burners are of older design and trim is set manually.

Replacement of burners and combustion controls will provide a marked improvement in firing efficiency.

Energy Savings Calculation

Firing efficiencies measured are shown above for existing boilers.
The older burners can be replaced with burners which can provide firing efficiencies of 83% for fuel oil and 75% for LPG, including the effects of oxygen trim controls, which can improve efficencies from between 1.5% and 3.0%, alone.

Assume firing efficency improvement to 83% for Fuel oil use and 75% for LPG use for energy energy saving calculations.

	LPG	No 2 FO	Total
FY93 Energy Use (Mil BTU/Yr)	1,496	1,615	3,111
Existing Avg. Plant Efficiency	46.5%	54.5%	50.5%
FY93 Plant Load (Mil BTU/Yr)	696	880	1,576
Improved Plant Efficiency	60.5%	68.5%	64.5%
Future Energy Use (Mil BTU/Yr)	1,150	1,285	2,435
Energy Savings (Mil BTU/Yr)	346	330	676
Energy Costs ($/Mil BTU)	$7.37	$13.25	-
Energy Cost Saved ($/Year)	$2,551	$4,373	$6,924
LCC UPV Factor; N=15 Years	13.25	12.18	Region 4, Industrial
LCC Fuel Costs Saved ($)	$33,804	$53,265	$87,069

Added O&M Costs

Assume 40 MH/Year at $22/MH x 1.5 (Benefits/OH) are required to maintain Oxygen Trim Controls over present maintenance practices:

Annual Additional O&M Cost	$1,320	per Year added Cost
LCC UPV Factor; N=15 Years	10.74	
LCC O&M Cost Added	$14,177	

Economic Evaluation Measures

Costruction Cost (See Estimate)	$55,572	
SIOH & Design, each @ 6%	$6,669	
Investment ($)	$62,241	
SIR	1.17	**Project Recommended**
Paypack Period (Years)	11.11	

Engineered turbulators installed in fire tubes cause combustion gasses to pass thru tubes with more turbulence than do the short "spinners" normally installed standard with the boilers. Heat transfer is improved, increasing boiler efficiency.

Engineered turbulators, designed by the manufacturer provide for more uniform distribution of combustion gases through the tube assembly.

Energy Savings Calculation

Energy savings of between 10% and 15% are achievable. Assuming, conservatively, a 10% savings, and implementation of ECO B1 prior to installing turbulators, energy savings are:

	LPG	No 2 FO	Total
ECO B1 Energy Use (Mil BTU/Yr)	1,150	1,285	2,435
ECO B1 Avg. Plant Efficiency	60.5%	68.5%	64.5%
ECO B1 Plant Load (Mil BTU/Yr)	696	880	1,576
Improved Plant Efficiency	70.5%	78.5%	74.5%
Future Energy Use (Mil BTU/Yr)	987	1,121	2,108
Energy Savings (Mil BTU/Yr)	163	164	327
Energy Costs ($/Mil BTU)	$7.37	$13.25	-
Energy Cost Saved ($/Year)	$1,202	$2,169	$3,371
LCC UPV Factor; N=15 Years	13.25	12.18	Region 4, Industrial
LCC Fuel Costs Saved ($)	$15,926	$26,414	$42,340

Added O&M Costs

Pull & reinstall turbulators @ annual boiler inspection, clean components: 1/2 installation cost (boiler must be opened for inspection with or without turbulators) x 1.5 for benefits/OH:

Annual Additional O&M Cost	$519	per Year added Cost
LCC UPV Factor; N=15 Years	10.74	
LCC O&M Cost Added	$5,574	

Economic Evaluation Measures

Construction Cost (See Estimate)	$1,952	
SIOH & Design, each @ 6%	$234	
Investment ($)	$2,186	
SIR	16.82	**Project Recommended**
Paypack Period (Years)	0.77	

Boiler Efficiency Improvement Project B3

Automatic Blowdown with Heat Recovery

Installation of continuous blowdown controls with heat recovery to heat makeup water via a small shell and tube heat exchanger will save heating energy lost for surface blowdown.

Most boiler surface blowdown losses represent about 3% of energy use. This is due to excessive blowdown quantities when performed manually.

Boiler operations at Building 506 were observed. Chemical test of boiler water disolved and suspended solids build-up are conducted and manual blowdown is controlled to minimum amounts.

Energy Savings Calculation

Automatic boiler blowdown quantity saved:

Existing Blowdown	2.00%
Automatic Blowdown	1.75%
Savings	0.25%

Heat recovery to Makeup water:
Delta T = (212 - 60) Deg F = 152 Deg F

	LPG	No 2 FO	Total	
Egy Use after ECO B2 (Mil BTU/Yr)	987	1,121	2,108	
ECO B2 Load (Mil BTU/Yr)	696	880	1,576	
BD @ 2% & 1,000 BTU/# Stm	13,915	17,602	31,517	#/Year
BD @ 1.75% & 1,000 BTU/# Stm	12,176	15,402	27,578	#/Year
BD Saved	1,739	2,200	3,940	#/Year
Load Saved @ 152 Deg F Delta T	0.26	0.33	0.60	Mil BTU/Year
Heat Recovered @ 70% Efficiency	1.30	1.64	2.93	Mil BTU/Year
Total Load Savings	1.56	1.97	3.53	Mil BTU/Year
New Load (Mil BTU/Yr)	694	878	1,572	
Improved Plant Efficiency @ B2	70.5%	78.5%	74.5%	
Future Energy Use (Mil BTU/Yr)	985	1,119	2,103	
Energy Savings (Mil BTU/Yr)	2.21	2.51	4.73	
Energy Costs ($/Mil BTU)	$7.37	$13.25	-	
Energy Cost Saved ($/Year)	$16.30	$33.31	$49.61	
LCC UPV Factor; N=15 Years	13.25	12.18	Region 4, Industrial	
LCC Fuel Costs Saved ($)	$216	$406	$622	

O & M Cost Savings

Maintenance for the proposed new system is assumed minimal, about 1 hour per year per system added tasks. Manual blowdown presently consumes about 2 to 3 (say 2) hours per week of operator labor. Thus, O&M labor savings are: 103 hours per year saved.

At $22/MH x 1.5 for Benifits/OH:

Annual O&M Cost Savings	$6,798	per Year Cost Savings
LCC UPV Factor; N=15 Years	10.74	
LCC O&M Cost Saved	$73,011	

Economic Evaluation Measures

Construction Cost (See Estimate)	$14,555	
SIOH & Design, each @ 6%	$1,747	
Investment ($)	$16,301	
SIR	4.52	**Project Recommended**
Paypack Period (Years)	2.38	

Boiler Efficiency Improvement Project B4

New Boilers for Present Uses

Existing boilers each have a capacity to generate 4,315 pounds per hour of steam. Steam is used to heat hot water in heat exchangers for space heating and for domestic hot water (DHW). Steam was used previously for cooking and dishwashing in the dining facility. (Dining facility is no longer used for this purpose.)

Existing boilers are oversized for their present use. The lack of use of the dining facility and changes in use from a dormatory to office functions for part of the building causes heat load to be reduced. Additional savings in heating load are provided by the recent addition of exterior wall insulation.

Installation of smaller boilers to accomodate non-heating season heating needs will reduce losses from boiler cycling and provide heating at efficiencies only available with modern boilers.

Energy Savings Calculation

Option B4A

Efficiencies, comparable to those developed above, of modular boiler installation (@ Hydrotherm) is 76.6% on No. 2 Fuel Oil and 75.8% on Natural Gas/LPG. Compared to existing efficiencies and energy use (without implementation of ECO's B1 or B2):

	LPG	No 2 FO	Total
Existing Energy Use (Mil BTU/Yr)	1,496	1,615	3,111
Existing Avg. Plant Efficiency	46.5%	54.5%	50.5%
Existing Plant Load (Mil BTU/Yr)	696	880	1,576
B4 Improved Plant Efficiency	75.8%	76.6%	-
Future Energy Use (Mil BTU/Yr)	918	1,149	2,067
Energy Savings (Mil BTU/Yr)	578	466	1,044
Energy Costs ($/Mil BTU)	$7.37	$13.25	-
Energy Cost Saved ($/Year)	$4,262	$6,173	$10,435
LCC UPW Factor; N=15 Years	13.25	12.18	Region 4, Industrial
LCC Fuel Costs Saved ($)	$56,467	$75,192	$131,658

Option B4B

Fuel use for DHW heating is based on fuel deliveries as shown above. DHW energy use appears to be about 800 gallons/Month of No. 2 FO (conservative estimate). Assume a distribution between LPG and No. 2 FO is the same as for annual fuel use:

12 x 800 Gallons/Mo x 138,700 BTU/Gal = 1,332 Million BTU/Year

	LPG	No 2 FO	Total	
Present DHW Fuel Use	640	692	1,332	Mil BTU/Yr
Existing Avg. Plant Efficiency	46.5%	54.5%	50.5%	
Existing Plant Load (Mil BTU/Yr)	297	377	674	
B4 Improved Plant Efficiency	75.8%	76.6%	-	
Future Energy Use (Mil BTU/Yr)	392	492	885	
Energy Savings (Mil BTU/Yr)	247	200	447	
Energy Costs ($/Mil BTU)	$7.37	$13.25	-	
Energy Cost Saved ($/Year)	$1,822	$2,644	$4,467	
LCC UPW Factor; N=15 Years	13.25	12.18	Region 4, Industrial	
LCC Fuel Costs Saved ($)	$24,144	$32,209	$56,353	

New Boiler Sizing

Existing boilers are sized at 4,315 #/Hr steam production; 4,187,500 BTUH output.
As shown in ECO B1 calculations, average existing plant efficiency is 50.5%. Thus, design load per boiler is: 4.1875 / 0.505 = 8.29 Million BTUH

0.505

Building use has changed:
- Fewer residents
- Some rooms changed to offices
- Dining facility is closed
- Exterior wall insulation added to building
- Roof insulation added

Significantly reduced loads resulting from these changes causes existing steam boilers to cycle frequently.

Domestic Hot Water generator loads include dining facility and residents. With a population of 200 residents and 30 gpcd of 140 Deg F Hot Water use (60 Deg F CW temperature assumed): 4.008 Million BTU/Day Load

Assume 2.004 Million BTUH Load (conservative)

Load reduction due to wall insulation: Assume U = 0.40 for wall before insulation added and U = 0.05; energy savings are: 36,000 SF Wall Area

70 - 39 Deg F 31 Deg F Delta T

390,600 BTUH load saved from Wall Insulation

Population DHW Load Reduction: Population reduced to 50% from design:

1.002 Million BTUH Load reduction

Non-use of dining facility: Booster heater uses 185 Deg F water, steam uses in cooking kettles, dishwashing, etc, account for about:

1.5 Million BTUH Load reduction

Overall Load Reduction = 2.893 Million BTUH Total Load reduction

Assuming the original boiler plant was sized for 150% of total load, the original load for heating and DHW heating is: 5.583 Million BTUH Original DHW Load

Option B4A

The new, reduced load for heating and DHW is: (2 x 4.1875 MBTUH / 1.5)

Replaces existing boilers until dining facility reopened **- 2.893 MBTU =**

2.691 Million BTUH New, Reduced Load DHW and Heating Services

Option B4B

If new boilers selected only for DHW heating service during non-heating season, and allowing for 150% of reduced load: 1.5 x 1.002 Million BTUH =

Replaces existing boiler use only during non-heating season.

1.503 Million BTUH New, Reduced Load DHW Services Only, Non-heating season

O&M Cost Savings

One operator attends existing steam boilers a minimum of 3 hours per day, 5 days per week. Use of new HW boilers does not require operator attendance. Annual labor cost savings are calculated for both options assuming 780 Hrs/Yr, $22/Hr x 1.5 for benefits/OH:

Option B4A	$25,740	per year saved from existing operator

Assume 240 Hr/Yr maintenance is required for new boilers and for existing boilers, to be kept moth-balled.

	($7,920)	per year maintain existing & new systems
Net O&M Savings =	$17,820	per Year
LCC UPV Factor; N=15 Years	10.74	
LCC O&M Costs Saved	$191,387	

Option B4B	$12,870	per year saved from existing operator for 1/2 year operations

Assume 450 Hr/Yr maintenance is required for new boilers and for existing boilers, to be kept moth-balled.

	($14,850)	per year maintain existing & new systems
Net O&M Savings =	($1,980)	per Year
LCC UPV Factor; N=15 Years	10.74	
LCC O&M Costs Saved	($21,265)	

Economic Evaluation Measures - Projects B4A & B4B

Option B4A

Costruction Cost (See Estimate)	$109,429	
SIOH & Design, each @ 6%	$13,131	
Investment ($)	$122,560	
SIR	2.64	**Project Recommended**
Paypack Period (Years)	4.34	

Option B4B

Costruction Cost (See Estimate)	$66,003	
SIOH & Design, each @ 6%	$7,920	
Investment ($)	$73,923	
SIR	0.47	**Project Not Recommended because**
Paypack Period (Years)	29.73	**Option B4A has better results**

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Building 506 Boiler Efficiency Improvements Project B-1

Location: Yuma Proving Ground, Arizona Region No. 4 — Project No.
Project Title: Boiler Efficiency Improvements, ECO B-1 — Fiscal Year FY96
Discrete Portion Name: Building 506 New Burners & O2 Trim — Preparer: KELLER & GANNON
Analysis Date: January 1994 — Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 55,572		
B. SIOH	$ 3,334		
C. Design Cost	$ 3,334		
D. Total Cost (1A+1B+1C)	$ 62,241		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$62,241

2. Energy Savings (+)/Cost(-):
Date of NISTIR 85-3273-X Used for Discount Factors

Energy Source	Cost $/MBTU	Saving MBtu/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.00	0.0	$0	11.30	$0
B. Dist	$13.25	330	$4,373	12.18	$53,257
C. LPG	$7.37	346	$2,550	13.25	$33,788
D. Other					
E. Demand Savings					
F. Total		676	$6,923		$87,045

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($1,320)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($14,177)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) — ($14,177)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)): 11.1 Years
5. Total Net Discounted Savings (2F5+3C): $72,868
6. Savings to Investment Ratio (SIR) 5/1G: 1.17
7. Adjusted Internal Rate of Return (AIRR): 5.60%

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Σ

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Building 506 Boiler Efficiency Improvements Project B-2

Location: Yuma Proving Ground, Arizona Region No. 4 | Project No.
Project Title: Boiler Efficiency Improvements, ECO B-2 | Fiscal Year FY96
Discrete Portion Name: Building 506 - Turbulators for 2 Boilers | Preparer: KELLER & GANNON
Analysis Date: January 1994 | Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 1,952		
B. SIOH	$ 117		
C. Design Cost	$ 117		
D. Total Cost (1A+1B+1C)	$ 2,186		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$2,186

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors

Energy Source	Cost $/MBTU	Saving MBtu/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.00	0.0	$0	11.30	$0
B. Dist	$13.25	164	$2,169	12.18	$26,419
C. LPG	$7.37	163	$1,202	13.25	$15,927
D. Other					
E. Demand Savings					
F. Total		327	$3,371		$42,346

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($519)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($5,574)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($5,574)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	0.77	Years
5. Total Net Discounted Savings (2F5+3C):	$36,772	
6. Savings to Investment Ratio (SIR) 5/1G:	16.82	
7. Adjusted Internal Rate of Return (AIRR):	26.14%	

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Building 506 Boiler Efficiency Improvements Project B-3

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Boiler Efficiency Improvements, ECO B-3 Fiscal Year FY96
Discrete Portion Name: Bldg 506 Automatic Blowdown with Heat Recove Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 14,555		
B. SIOH	$ 873		
C. Design Cost	$ 873		
D. Total Cost (1A+1B+1C)	$ 16,302		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$16,302

2. Energy Savings (+)/Cost(-):
Date of NISTIR 85-3273-X Used for Discount Factors

Energy Source	Cost $/MBTU	Saving MBtu/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.00	0.00	$0.00	11.30	$0
B. Dist	$13.25	2.51	$33.31	12.18	$406
C. LPG	$7.37	2.21	$16.30	13.25	$216
D. Other					
E. Demand Savings					
F. Total		4.73	$49.61		$622

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	$6,798		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			$73,011

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) $73,011

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	2.38	Years
5. Total Net Discounted Savings (2F5+3C):	$73,632	
6. Savings to Investment Ratio (SIR) 5/1G:	4.52	
7. Adjusted Internal Rate of Return (AIRR):	15.55%	

Life Cycle Cost Analysis Summary

Energy Conservation Investment Program (ECIP)

Building 506 Boiler Efficiency Improvements Project B-4A

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.

Project Title: Boiler Efficiency Improvements, ECO B-4A Fiscal Year FY96

Discrete Portion: Bldg 506 New Modular Boilers for Heating & DHW Serv Preparer: KELLER & GANNON

Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 109,429		
B. SIOH	$ 6,566		
C. Design Cost	$ 6,566		
D. Total Cost (1A+1B+1C)	$ 122,560		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$122,560

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/MBTU	Saving MBtu/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.00	0.0	$0	11.30	$0
B. Dist	$13.25	466	$6,173	12.18	$75,189
C. LPG	$7.37	578	$4,262	13.25	$56,472
D. Other					
E. Demand Savings					
F. Total		1044	$10,435		$131,662

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	$17,820		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			$191,387

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) $191,387

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	4.34	Years
5. Total Net Discounted Savings (2F5+3C):	$323,049	
6. Savings to Investment Ratio (SIR) 5/1G:	2.64	
7. Adjusted Internal Rate of Return (AIRR):	11.47%	

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Building 506 Boiler Efficiency Improvements Project B-4B

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Boiler Efficiency Improvements, ECO B-4B Fiscal Year FY96
Discrete Portion: Bldg 506 Modular Boilers - DHW Heating - Non Htg Sea Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 66,003		
B. SIOH	$ 3,960		
C. Design Cost	$ 3,960		
D. Total Cost (1A+1B+1C)	$ 73,923		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$73,923

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/MBTU	Saving MBtu/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.00	0.0	$0	11.30	$0
B. Dist	$13.25	200	$2,644	12.18	$32,209
C. LPG	$7.37	247	$1,822	13.25	$24,145
D. Other					
E. Demand Savings					
F. Total		447	$4,467		$56,354

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($1,980)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($21,265)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($21,265)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	29.73	Years
5. Total Net Discounted Savings (2F5+3C):	$35,089	
6. Savings to Investment Ratio (SIR) 5/1G:	0.47	
7. Adjusted Internal Rate of Return (AIRR):	-0.56%	

CONSTRUCTION COST ESTIMATE		Date Prepared: January 1994		Sheet Of
Project: EEAP Limited Energy Study		Project No.	Basis for Estimate: Code A (no design competed)	
Location: Yuma Proving Ground, Arizona				
Engineer-Architect: Keller & Gannon				
Drawing No.	Estimator: JRB		Checked By: BIH	

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
ECO B-1 Replace Burners & Add O2 Trim							
Burner Replacement	2	EA	$850	$1,700	$5,200	$10,400	$12,100
(Incl. Mtng Plate & Gas String)							
O2 Trim Controls, Complete	2	EA	-	-	$11,000	$22,000	$22,000
Install O2 Trim	60	MH	$43	$2,595	-	-	$2,595
Subtotal				$4,295		$32,400	$36,695
State Sales Tax	5.5%	%		-		$1,782	$1,782
Subtotal							$38,477
Contractor OH & Profit	30.0%	%					$11,543
Subtotal							$50,020
Bond	1.0%	%					$500
Subtotal							$50,520
Estimating Contingency	10.0%	%					$5,052
Total Probable Construction Cost							$55,572

Line Item	No. Units	Unit Meas.	Labor Per Unit	Labor Total	Material Per Unit	Material Total	Total Cost
B-2 Install Turbulators							
Tubes	50	Tube	-	-	$13	$625	$625
Installation	16	MH	$43	$692	-	-	$692
Subtotal				$692		$625	$1,317
State Sales Tax	5.5%	%		-		$34	$34
Subtotal							$1,351
Contractor OH & Profit	30.0%	%					$405
Subtotal							$1,757
Bond	1.0%	%					$18
Subtotal							$1,774
Estimating Contingency	10.0%	%					$177
Total Probable Construction Cost							$1,952

CONSTRUCTION COST ESTIMATE

CONSTRUCTION COST ESTIMATE	Date Prepared: January 1994	Sheet Of
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: Code A (no design competed)
Location: Yuma Proving Ground, Arizona		
Engineer-Architect: Keller & Gannon		
Drawing No.	Estimator: JRB	Checked By: BIH

Line Item	Quantity No. Units	Quantity Unit Meas.	Labor Per Unit	Labor Total	Material Per Unit	Material Total	Total Cost
ECO B-3 Automatic Boiler Blowdown with Heat Recovery							
Blowdown System Auto w/ Sensors	2	EA	$297	$594	$2,600	$5,200	$5,794
Heat Exchanger	2	EA	$178	$357	$1,225	$2,450	$2,807
Piping & Fittings 2" Dia Galvanized	40	LF	$14	$558	$5.00	$200	$758
Ball Valves 2" Dia	5	EA	$23	$113	$33	$165	$278
Subtotal				$1,621		$8,015	$9,636
State Sales Tax	5.5%	%		-		$441	$441
Subtotal							$10,077
Contractor OH & Profit	30.0%	%					$3,023
Subtotal							$13,100
Bond	1.0%	%					$131
Subtotal							$13,232
Estimating Contingency	10.0%	%					$1,323
Total Probable Construction Cost							$14,555

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet Of
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: Code A (no design competed)
Location: Yuma Proving Ground, Arizona		
Engineer-Architect: Keller & Gannon		
Drawing No.	Estimator: JRB	Checked By: BIH

Line Item	Quantity		Labor		Material		Total
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Cost
ECO B-4A Heating Hot Water							
MOP-3850-10Mod Hydrotherm HW Boiler	1	EA	$9,400	$9,400	$30,015	$30,015	$39,415
Burners BM-4133 Dual	10	EA	$300	$3,000	$2,600	$26,000	$29,000
4" Dia. Pipe-Allow. (Galv.) 151-701-2110	200	LF	$11	$2,276	$9	$1,890	$4,166
Circulation Pump Base Mounted	2	EA	$255	$510	$1,250	$2,500	$3,010
Gate Valves 4" Dia.	12	EA	$136	$1,632	$345	$4,140	$5,772
Misc. Controls	-	Lot	-	$1,000	-	$2,000	$3,000
Shed - Enclosure	240	SF	$50	$12,000	$25	$6,000	$18,000
Flue/Stack 48" Dia.	70	LF	$33	$2,275	$380	$26,600	$28,875
Pipe Insulation 4" Dia. 2" Thick	200	LF	$6	$1,190	$5	$1,090	$2,280
Electrical - Allowance	-	Lot	-	$2,000	-	$1,000	$3,000
Subtotal				$14,676		$57,905	$72,581
State Sales Tax	5.5%	%		-		$3,185	$3,185
Subtotal							$75,766
Contractor OH & Profit	30.0%	%					$22,730
Subtotal							$98,496
Bond	1.0%	%					$985
Subtotal							$99,480
Estimating Contingency	10.0%	%					$9,948
Total Probable Construction Cost							$109,429

Line Item	No. Units	Unit Meas.	Labor Per Unit	Labor Total	Material Per Unit	Material Total	Total Cost
ECO B-4B Domestic Hot Water Only							
MOP-2310-6 Mod. Hydrotherm HW Boiler	1	EA	$6,000	$6,000	$20,323	$20,323	$26,323
Burners - BM-4133-Dual	6	EA	$300	$1,800	$2,600	$15,600	$17,400
4" Dia. Pipe-Allowance	100	LF	$11	$1,138	$9	$945	$2,083
Circulation Pump - Base Mounted	1	EA	$255	$255	$1,250	$1,250	$1,505
Gate Valves 4" Dia.	12	EA	$136	$1,632	$345	$4,140	$5,772
Misc. Controls	-	Lot	-	$1,000	-	$2,000	$3,000
Shed - Enclosure	120	SF	$50	$6,000	$25	$3,000	$9,000
Flue/Stack 32" Dia.	50	LF	$23	$1,125	$183	$9,150	$10,275
Pipe Insulation 4" Dia. 2" Thick	100	LF	$6	$595	$5	$545	$1,140
Electrical Allowance	-	Lot	-	$1,500	-	$750	$2,250
Subtotal				$7,800		$35,923	$43,723
State Sales Tax	5.5%	%		-		$1,976	$1,976
Subtotal							$45,699
Contractor OH & Profit	30.0%	%					$13,710
Subtotal							$59,408
Bond	1.0%	%					$594
Subtotal							$60,002
Estimating Contingency	10.0%	%					$6,000
Total Probable Construction Cost							$66,003

MODEL C-4400
Steam
125 H.P. 15-200 psig

MODEL CW-44
Hot Water
4187 MBH 30 psi

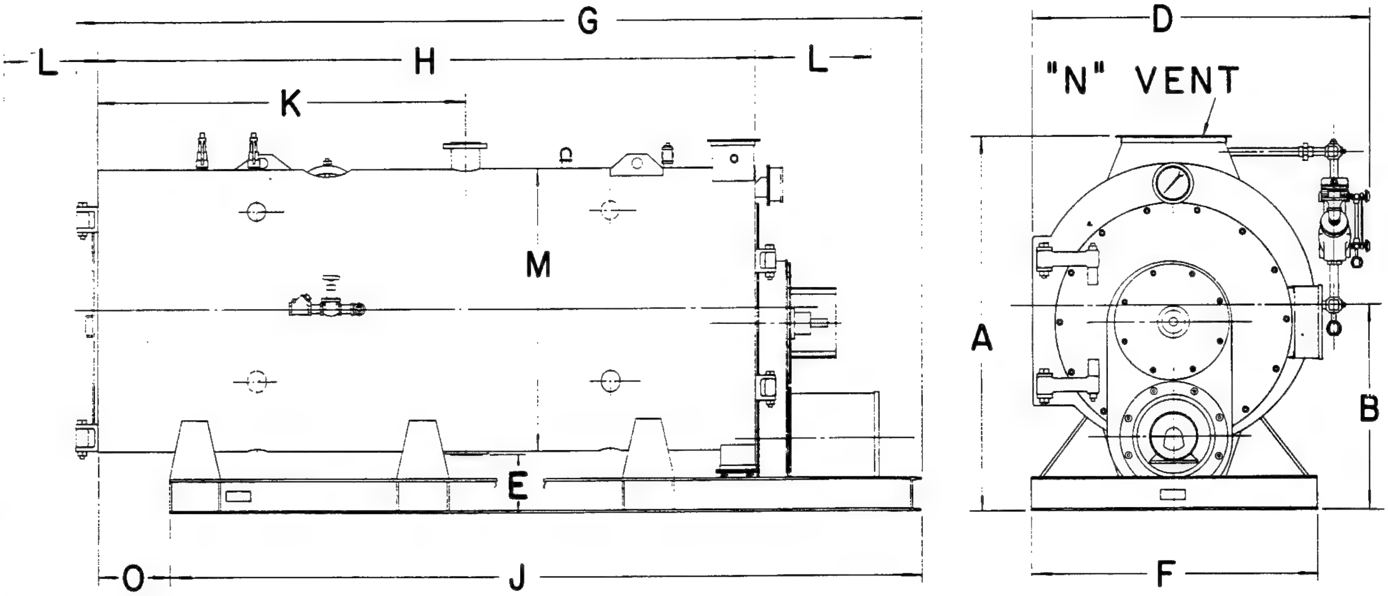
GAREN EDWARDS

CYCLOTHERM DIVISION OSWEGO PACKAGE BOILER CO., Inc.
OSWEGO, N. Y.

STEAM OR HOT WATER GENERATOR

for light oil, heavy oil and/or gas

Called Garen Edwards, Schoelke Co (415) 591-7392
for burner & turbulator retrofits. FAX: 591-0529



NOMINAL RATINGS	STEAM C	HOT WATER CW
Steam/Hr. from and @212°F	4315 lbs.	
Std. Design Pressure (psi)	15, 100-200	30
Equivalent (H.P.)	125	125
Btu Output	4,187,500	4,187,500
Gross (EDR)	17448	27197
DIMENSIONS		
HEIGHT		
Floor to Top of Flue Outlet ... A	76	81
Floor to C/L of Unit ... B	41	46
Floor to Return Opening ... E	NA	17
WIDTH		
Diameter of Shell ... M	58	60
Overall Width ... D	70	66
Base Mount ... F	60	61
LENGTH		
Overall ... G	174	163
Boiler Shell ... H	137	124
Base Mount ... J	153	149
From Rear to C/L Outlet ... K	73	62
Required for Tube Removal--Front or Rear ... L	117	100
End of Skid From Rear ... O	16	9
FLUE OUTLET		
Rectangular ... N	8 x 24	8 x 24

BOILER TRIM DIMENSIONS	STEAM C 15	STEAM C 100-200	HOT WATER CW
Outlet	8	4	5
Feed Water	1¼	1½	1¼
Return	3	NA	5
Blow Off	1½	1½	2
†† Safety or Relief Valve	3	1½	2-2
ELECTRICAL REQUIREMENTS			
@230 Volts/3 Phase			
Burner Motor (HP)	5		5
*Lt. Oil Pump (HP)	3/4		3/4
Hvy. Oil Pump (HP)	1½		1½
Preheater #4 Oil (KW)	6		6
† Preheater #6 Oil (KW)	8		8
FIRING RATES (Approximate)			
Light Oil (GPH)	37.5		37.5
Heavy Oil (GPH)	35		35
Manufactured Gas (CFH)	9695		9695
Natural Gas (CFH)	5235		5235
Mixed Gas (CFH)	6018		6018
CLEANOUT OPENING			
Handhole (six)	3½ x 4½		3½ x 4½
Comb. Cleanout-Relief Door-Rect.	5 x 12		6 x 6
Front and Rear Doors--Dia.	43½		47
Manhole	11 x 15		NA
WEIGHTS			
Domestic Shipping	12,000		12,000

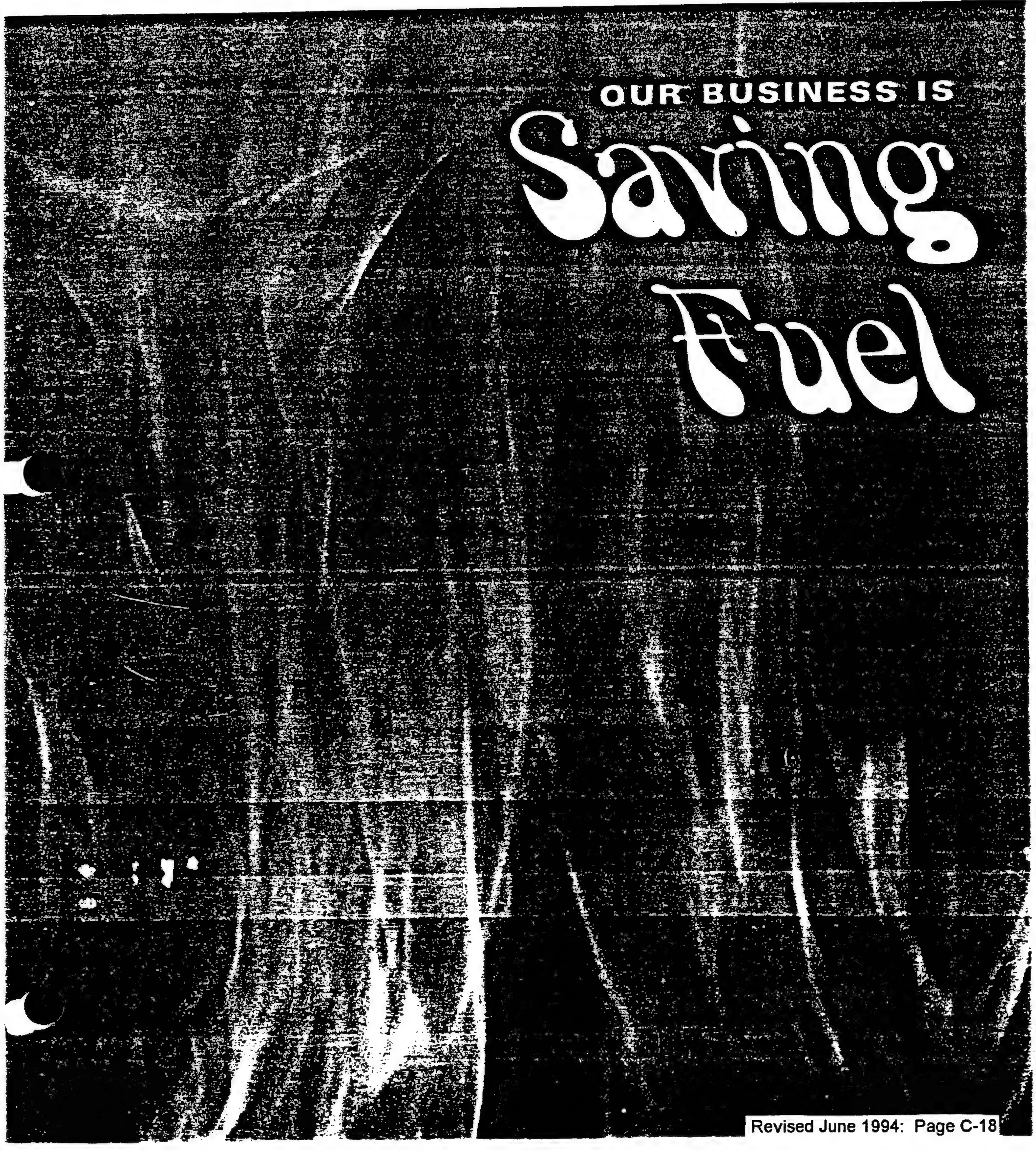
All Dimensions in Inches
NA - Not Applicable
*Motor Size on Light Oil and #4 Oil Are Same.
† Steam Units--Comb. Steam and Electric Preheaters.
Hot Water Units Separate Preheaters.
†† Two on 100 psi; one on all others.

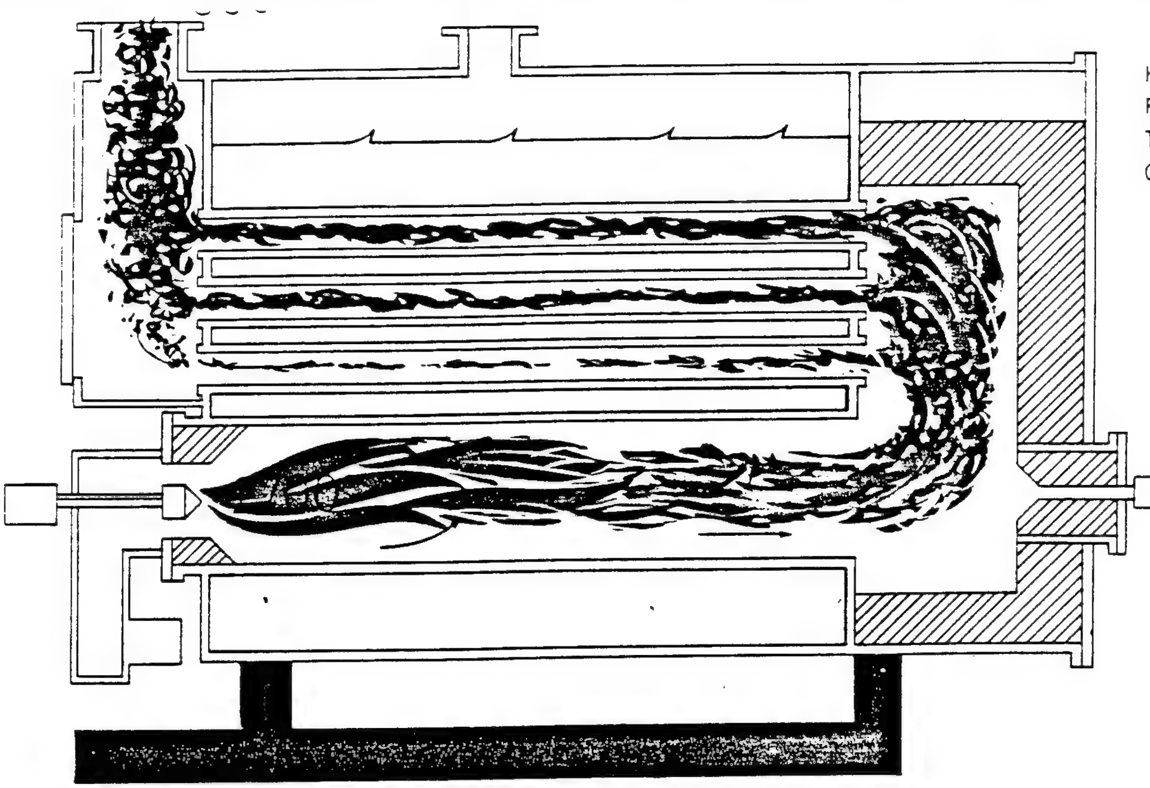
BROCK Fuel-Saver
TURBULATORS BY:

Fuel Efficiency

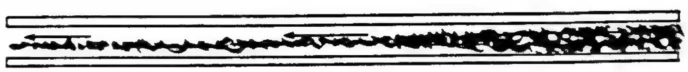
EC0B2

131 STUART AVENUE • NEWARK, NEW YORK STATE 14513





HOTTEST GAS FLOWS THRU TOP ROWS OF TUBES ONLY.



Two-Pass Scotch Boiler (shown above). Brock Turbulators are applicable to most firetube boiler designs.

Hot gases entering a tube are active and turbulent; but within a foot or two, they take on the shape of the tube, and slide the rest of the tube length in laminar flow. As the gases surrender their heat they contract and form a hot core. An invisible but substantial barrier of latent "dead" gases forms on the tube wall, greatly retarding heat transfer.

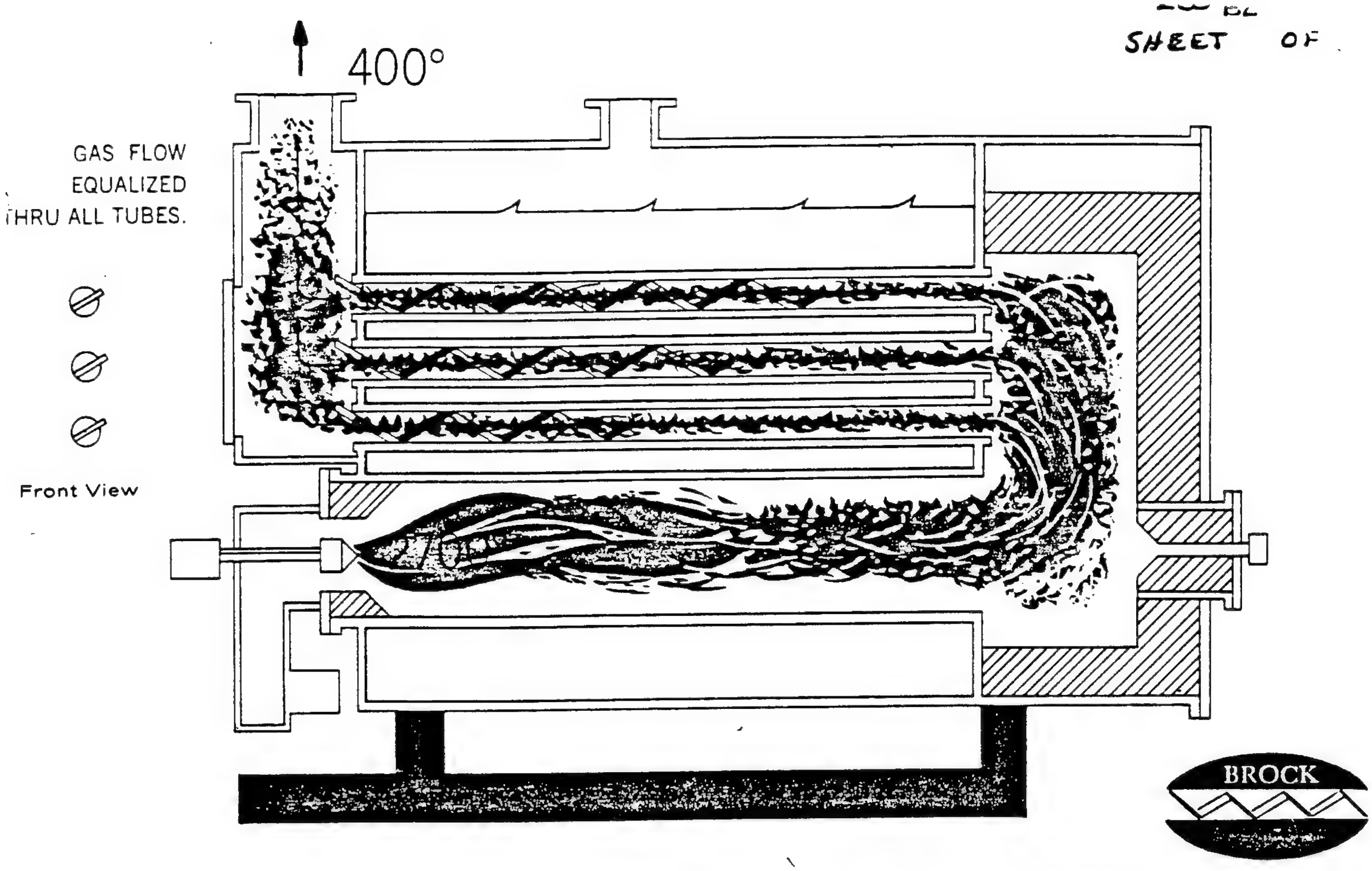
BROCK TURBULATOR FACTS FOR BOILER OWNERS AND ENGINEERS

BROCK "FUEL SAVER" TURBULATORS WILL —

- Reduce Fuel Consumption and/or Increase Boiler Ca[illegible]
- Improve Combustion by [illegible]
  - Increase CO_2 in combustion gases.
  - Balance draft thru all boiler tubes so that they do equal work.
  - Reduce stack temperature.
  - [illegible] combustion gases.
  - [illegible] velocity thru tubes and [illegible] to insure complete [illegible]
- [illegible] and Reduce Air Pollution [illegible]

[illegible] the switch to lighter fuel oils or gas firing at approximately the same annual fuel costs, while reducing soot emission and air pollution, fuel oil handling costs and the high annual maintenance costs experienced with residual fuels.

- Increase Useful Life of Boiler and Increased Heat Transfer Within the Boiler.
- Reduce Hot Spots and Uneven Heat Distribution on Boiler Tube Sheets.
- Reduce Maintenance and Service Costs.
- Reduce Soot Build-up and Resultant Fireside Corrosion.
- Break up the laminar flow or hot core of gases in [illegible] and induce turbulence to obtain maximum heat transfer. The turbulent combustion gases [illegible] forced into intimate contact with tube wal[illegible]



Two-Pass Scotch Boiler (shown above) with Brock Turbulators.

Brock Turbulators break up the hot core and force the heat into intimate contact with the tube wall, creating a scrubbing action. This sweeps away the insulating "dead" gases allowing greatly improved radiation. In actual practice, stack temperatures have been dropped 90° to 385°.

sweep away insulating inert gases, improving radiation and heat absorption.

Improve Waterside Circulation to reduce thermal stresses in boiler shell.

Reduce Standby Losses and free flow of ambient air thru boiler and over refractory surfaces when burner is off, between demands for boiler operation.

Improve Boiler Operation with all fuels ranging from No. 2 to No. 6 fuel oil and gas. (Not recommended for coal fired boilers).

Boiler Tubes will stay clean longer due to more complete combustion and scrubbing of flue gases resulting from proper turbulence.

The Use of Brock Turbulators in conjunction with air or steam soot blowers will improve soot blower performance.

Each Brock "Fuel-Saver" Installation is custom designed, engineered and applied to *your* boiler to meet *your* specific boiler needs.

Full five (5) year warranty. (A copy of our warranty will be forwarded upon request.)

As a result of the proven performance of Brock Turbulators, several boiler companies are using them as an original equipment installation.

Brock Turbulators are being used for various installations, including: School Systems, Colleges, Institutions, Chemical Industry, Greenhouses, Department Stores, Apartment Houses, Government Agencies, Laundries, Office Buildings, Hotels, Dairies, Meat Packing Plants, Brewing Companies, and many others.

IF YOU OPERATE FIRETUBE BOILERS

Brock Turbulators will reduce your annual fuel costs for heating (both steam and hot water) or process steam requirements.

or

Increase your existing boiler output to meet your expanding manufacturing needs and additional heating loads.

ECO B2
SHEET OF

Mr. Manufacturer,

can you envision 10% to 15% of your present fuel bill being converted to a new profit?

Mr. School Administrator,

can you envision 10% to 15% of your present fuel bill being converted to athletic equipment, library or text books for the benefit of your students?

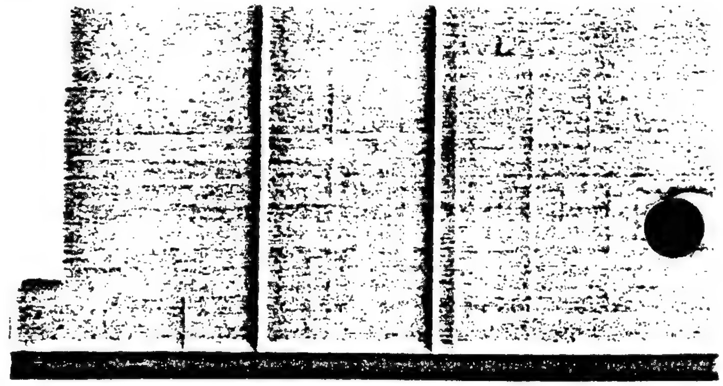
Mr. Apartment House Owner,

can you envision 10% to 15% of your present fuel bill being converted to a net income from an additional apartment you don't have to rent or maintain?

Brock Turbulators are the result of 16 years of research, development, application and testing in thousands of successful installations nationwide in firetube boilers of all types and designs.

A comprehensive study of many tests performed on the above installations indicate an improvement of 32.5% in CO_2 readings and a reduction of exit gas temperatures by 27.9% resulting in fuel savings and/or increased boiler capacity ranging from 10 to 15%.

Brock "Fuel-Saver" Turbulators are now being used by a half dozen manufacturers at the O.E.M. level for new boiler equipment and conversion burner applications. In addition, they are available through combustion equipment sales representatives throughout the U.S. and Canada.



good news for those who want to make scarce fuel supplies go farther and save money, too!

- Turbulators are low-cost and install easily without boiler modification.
- Turbulators will not damage your boilers.
- Turbulators help boilers operate more cleanly.
- In most cases Turbulators pay for themselves the first year of operation.
- Turbulators are available for prompt delivery to save you money this season.

Fuel Efficiency INC.

131 STUART AVENUE
P.O. BOX 48
NEWARK, NEW YORK STATE 14513
PHONE: (315) 331-3272
(315) 331-3276

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For Sales and Service
CALL

L. O. SCHUELKE CO., INC.
1313 Laurel Street
San Carlos, Calif. 94070
(415) 591-7392

PRODUCT DATA
Multi-Temp MOP Series Dual-Fuel Hydronic Modular Boiler Heating Plant

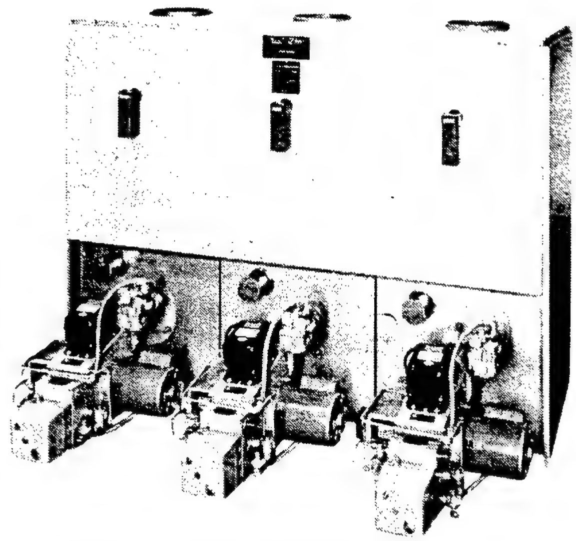
Innovators in energy conservation®

HYDROTHERM

A Division of Automation Industries, Inc.

DESCRIPTION

Multi-Temp dual fuel hydronic (water) modular heating plants, 770,000 to 6,930,000 Btuh input and larger, are equipped with burners capable of firing Number 2 fuel oil/natural gas or propane gas as desired and are designed for operation where fuel economies can be accomplished by selection of desired fuel. Ideally suited for heavy duty space heating, large volume water heating or a combination of space/volume water heating with external heat exchanger. Maximum efficiency is attained by step-firing only the modules which are required to satisfy the heating demand. For additional information, see Hydrotherm Engineering Manual.



STANDARD FEATURES

- UL listed Number 2 fuel oil/natural gas or propane gas burner field mounted on modules.
- Burner safety control locks out burner in case of flame failure.
- Air flow switch shuts off fuel upon loss of combustion air.
- Pressure regulator regulates gas pressure delivered to burner.
- Modules are supplied with standard cast iron absorption units.
- Natural draft firing.
- Gray hammertone, steel insulated jacket.
- Available with Gordon Piatt or ABC Sunray burners.
- Soft refractory combustion chamber in heavy metal base.
- ASME pressure relief valves.
- Cast iron domes.
- Temperature/pressure indicator.

BOILER MODEL (1)	NO. OF MODS.	INPUT (MBH)	OIL (GPH)	IBR GROSS OUTPUT (MBH)	NET OUTPUT (MBH) (2)	WATER CONTENT (GALS)	HORSE-POWER	SHIP WT (LBS)
MOP-770	2	770	5.50	584	508	13.4	17.42	1145
MOP-1155	3	1155	8.25	876	762	20.1	26.13	1720
MOP-1540	4	1540	11.00	1168	1016	26.8	34.83	2288
MOP-1925	5	1925	13.75	1460	1269	33.5	43.56	2860
MOP-2310	6	2310	16.50	1752	1523	40.2	52.27	3435
MOP-2695	7	2695	19.25	2044	1777	46.9	60.98	4000
MOP-3080	8	3080	22.00	2336	2031	53.6	69.69	4575
MOP-3465	9	3465	24.75	2628	2285	60.3	78.40	5150
MOP-3850	10	3850	27.50	2920	2539	67.0	87.11	5715
MOP-4235	11	4235	30.25	3210	2791	73.7	95.76	6290
MOP-4620	12	4620	33.00	3500	3043	80.4	104.42	6865
MOP-5005	13	5005	35.75	3800	3304	87.1	113.37	7430
MOP-5390	14	5390	38.50	4090	3556	93.8	122.02	8005
MOP-5775	15	5775	41.25	4380	3809	100.5	130.67	8580
MOP-6160	16	6160	44.00	4670	4061	107.2	139.32	9145
MOP-6545	17	6545	46.75	4960	4313	113.9	147.97	9720
MOP-6930	18	6930	49.50	5260	4574	120.6	156.92	10295

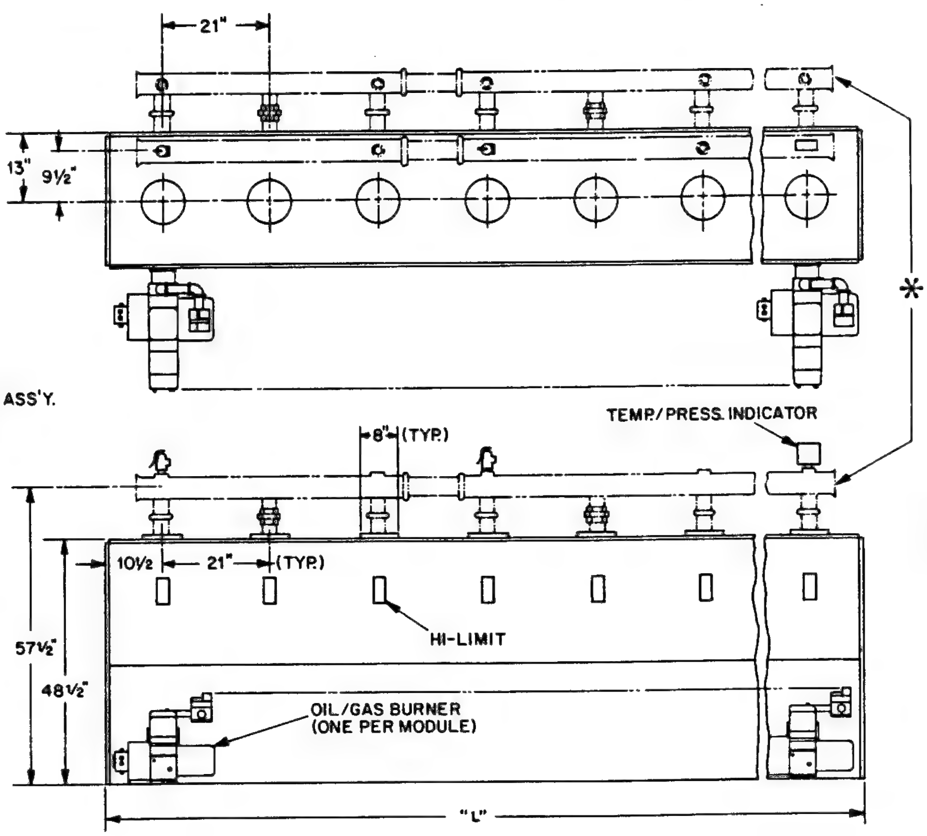
For larger sizes, consult Hydrotherm sales representative or Hydrotherm factory. (1) Model MOP equipped with Gordon Piatt [illegible] per sq. ft. EDR @ 170F average water temperature. For operation at altitudes above 2,000 feet above sea level, boiler input and ratings must be reduced 4% for each 1,000 feet above sea level.

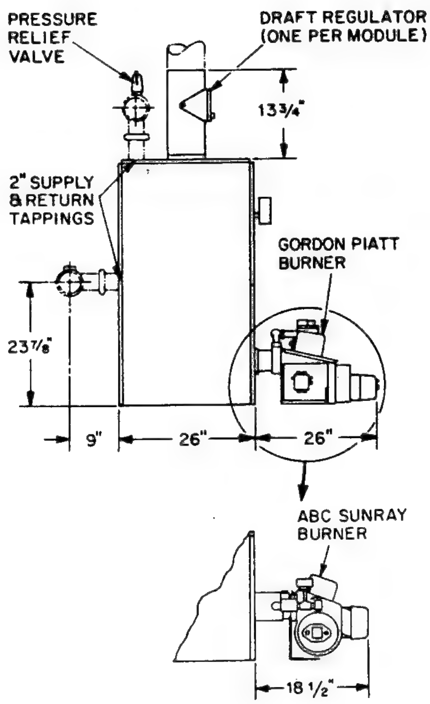
PRODUCT DATA MOP SERIES

BOILER MODEL	DIMENSIONAL DATA			
	LENGTH "L"	HEIGHT "H"	HEIGHT TO RETURN "A"	CHIMNEY SIZE INxINxFT
MOP-770	3′-6″	48½″	23⅞″	12x16x20
MOP-1155	5′-3″	48½″	23⅞″	12x16x20
MOP-1540	7′-0″	48½″	23⅞″	16x20x25
MOP-1925	8′-9″	48½″	23⅞″	20x20x25
MOP-2310	10′-6″	48½″	23⅞″	20x20x25
MOP-2695	12′-3″	48½″	23⅞″	20x20x25
MOP-3080	14′-0″	48½″	23⅞″	20x24x25
MOP-3465	15′-9″	48½″	23⅞″	20x24x25
MOP-3850	17′-6″	48½″	23⅞″	24x24x25

BOILER MODEL	DIMENSIONAL DATA			
	LENGTH "L"	HEIGHT "H"	HEIGHT TO RETURN "A"	CHIMNEY SIZE INxINxFT
MOP-4235	19′-3″	48½″	23⅞″	24x24x25
MOP-4620	21′-0″	48½″	23⅞″	24x28x25
MOP-5005	22′-9″	48½″	23⅞″	24x28x30
MOP-5390	24′-6″	48½″	23⅞″	24x28x30
MOP-5775	26′-3″	48½″	23⅞″	28x28x30
MOP-6160	28′-0″	48½″	23⅞″	28x28x30
MOP-6545	29′-9″	48½″	23⅞″	28x28x30
MOP-6930	31′-6″	48½″	23⅞″	28x28x30

DESIGN DATA PER MODULE
- Electrical Power Requirement: 115v/60Hz 7.5 Amps
- Working Pressure: 100 psi ASME
- Pressure Drop: 1.7 ft. w.c. at 30GPM (20FΔT)





*OPTIONAL:
For further information on Headers, refer to Header Product Data Sheet, H1.

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HYDROTHERM

A Division of Automation Industries, Inc.

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(416) 678-9383/TELEX 06-983583

Appendix D

Boiler Plant Efficiency Calculation Methods

Boiler Plant Efficiency Calculation Methods

Boiler Plant Efficiency

Boiler plant efficiency losses are a combination of the following losses:

- Combustion Efficiency Losses
- Auxiliary Equipment Energy Uses (2% to 6%)
- In-Plant Losses (7% to 15%), including:
  - Radiation losses (1% to 10%) (See Figure D-1)
  - Leaks in the boiler house (1% to 5%)
  - Equipment condition
  - Piping and tank insulation/conduction losses (2% to 5%)
  - Blowdown losses (1% to 5%)
  - Shutdown losses (1% to 4%)

Combustion Efficiency

Combustion efficiency can be determined by performing a heat and mass balance of the boiler. A complex methodology includes chemical analyses of flue gasses, the fuel and ash. A less complicated method involves measuring only CO_2 and temperature of flue gasses. The less complicated method gives results that are quite comparable to the complex method.

Combustion efficiency levels were conducted for oil fired boilers.

Auxiliary Equipment Uses

The range of losses is from 2% to 6% and includes such items as pumps, oil heating, steam tracing lines, etc. Assume most auxiliaries are power driven. These levels of consumption must be determined separately since electric power is used and the aim of these calculations is to determine fuel consumption levels. Assume only 10% of steam energy is used in auxiliaries.

In-Plant Losses

<u>Radiation Losses</u>: Use Figure D-1 on the following sheet for all boilers. Use a maximum value of 8% for these losses, since the graph is for delta T = 50 degrees F and most boiler rooms have high temperatures and stagnant air. Do not include additional losses due to less-than-maximum capacity operations.

<u>Blowdown Losses</u>: Most of the boiler plants investigated have manual blowdown. All boilers are blowdown manually each operating day. Blowdown occurs for a period of about 1 minute, but is quite variable depending on the operator. Manual

blowdown for a typical 1 x 10^6 BTUH boiler is about 2% (assuming a 50% load) for a hot water boiler as well as a steam boiler.

Leaks In Boiler House: Very few actual leaks have been found in steam, hot water or condensate piping. Assume only 0.5% for all installations. Combine with next item in "losses" listing.

Conduction/Convection Losses From Piping and Tanks: The following losses are based on a modeled typical boiler plant:

Condition of Installation	Good	Fair	Poor	None
Estimated Loss	1.0%	2.0%	2.5%	3.5%

Shutdown/Cycling Losses: Generally speaking, the more boilers shut down per day, the higher the losses will be. Assume the following demand per day:

For Plants with > or = 3 Boilers, Composit = 4% Losses (See table below)

Time of Day	Number of Boilers On Line		
	1	2	3
0000 - 0600	X		
0600 - 1000		X	
1000 - 1400			X
1400 - 1600		X	
1600 - 2000			X
2000 - 2200		X	
2200 - 2400	X		
8 Hours per Day 16 Hours per Day 24 Hours per Day	- - X	- X -	X - -

For Plants with 2 Boilers, assume 1 on 24 Hours per day & 2 on 16 Hours per day

3% Composite Loss, All others assume 2% Losses

Equipment Condition: An allowance of 3% additional losses is estimated for those plants in poor condition, 2% for those in fair-to-poor conditions and 1% in good condition.

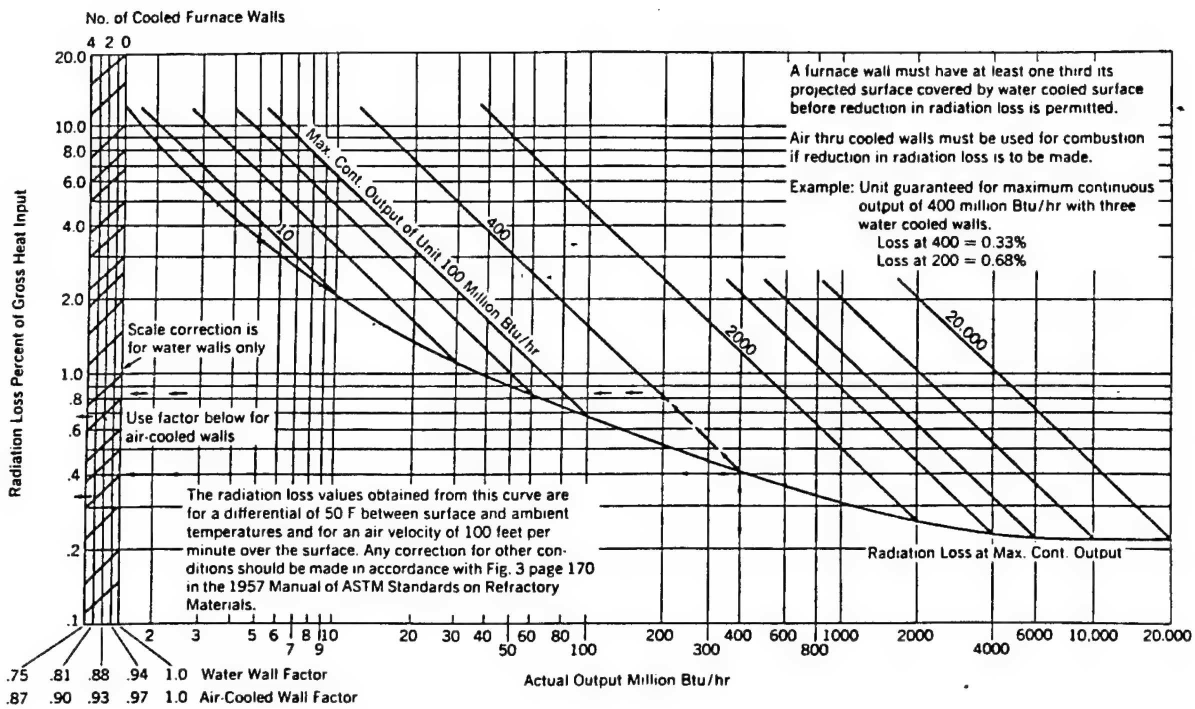


Figure D-1
Radiation Loss in Percent of Gross Heat Input

Source: American Boiler Manufacturers Association

Appendix E

Chiller Performance Data

APPENDIX E

Table of Contents

Chiller Performance Data

Introduction

Refrigeration systems serving six building heating, ventilating and air conditioning (HVAC) systems at Yuma Proving Ground (YPG) were subjected to an instrumented study of performance. The systems monitored included:

- 9 Chillers
    - 5 air-cooled
    - 4 water-cooled
- 2 Direct Expansion Cooling Systems

Data on power consumption and demand by the system, fluid and air temperatures and flow were recorded over at least a 24-hour period for each system. Results were tabulated and plotted on the following figures. Operating data measurements were made in 5-minute duration increments. As the data shows, measurements were always during partial load conditions.

Instrumentation / Data Collection

Instrumentation used for monitoring chiller (and direct expansion) system performance consisted of:

- Flow Meter (Water Flow): Multipurpose Ultrasonic Flow Meter, Mitchell Instrument Co. Mark 3, Model No. 4LM3902UP; + or — 5% accuracy, + or — 2% repeatability, FS = 0.5 to 20 FPS.

- Temperature: Fast response thermocouples with self adhesive backing, Omega Model. No. SA1-T, "T" type thermocouples.

- Data Loggers: Fluke Model No. FLU-2286/211, with math coprocessor, for recording flow and temperature data.

- Electric Power / Demand Analyzer: Dranetz Model No. DRN-808, data logging capability is built in.

Data was collected at 5 minute intervals for at least 24 hours for each chiller. Data was written to DOS format floppy disc for transport.

Data Reduction

Data was down loaded from the Dranetz load analyzers and from the Fluke data loggers into ASCII text format. The ASCII text was then imported into and converted to spreadsheet format for calculation purposes.

Data Analysis

Tabular data from electrical load measurements, flow and temperature data were combined into single spreadsheets and results plotted. The device Energy Efficiency Ratios (EERs) were also calculated and plotted with power consumption and cooling rates developed from the data. Plots for each monitoring effort are provided on the following pages.

The results were compared to manufacturer's claims of performance for their units. Where a comparison was possible, the refrigeration equipment seemed to be performing as designed. The time of year during which the monitoring was conducted made it difficult to rate peak load performance of systems as temperatures seldom exceeded 85°F. The design temperature at YPG is 111°F and often exceeds 120°F.

Figure E-1: Building 451 Chiller - Cooling Energy vs. EER

55 Ton Carrier 30GB-055-530AA

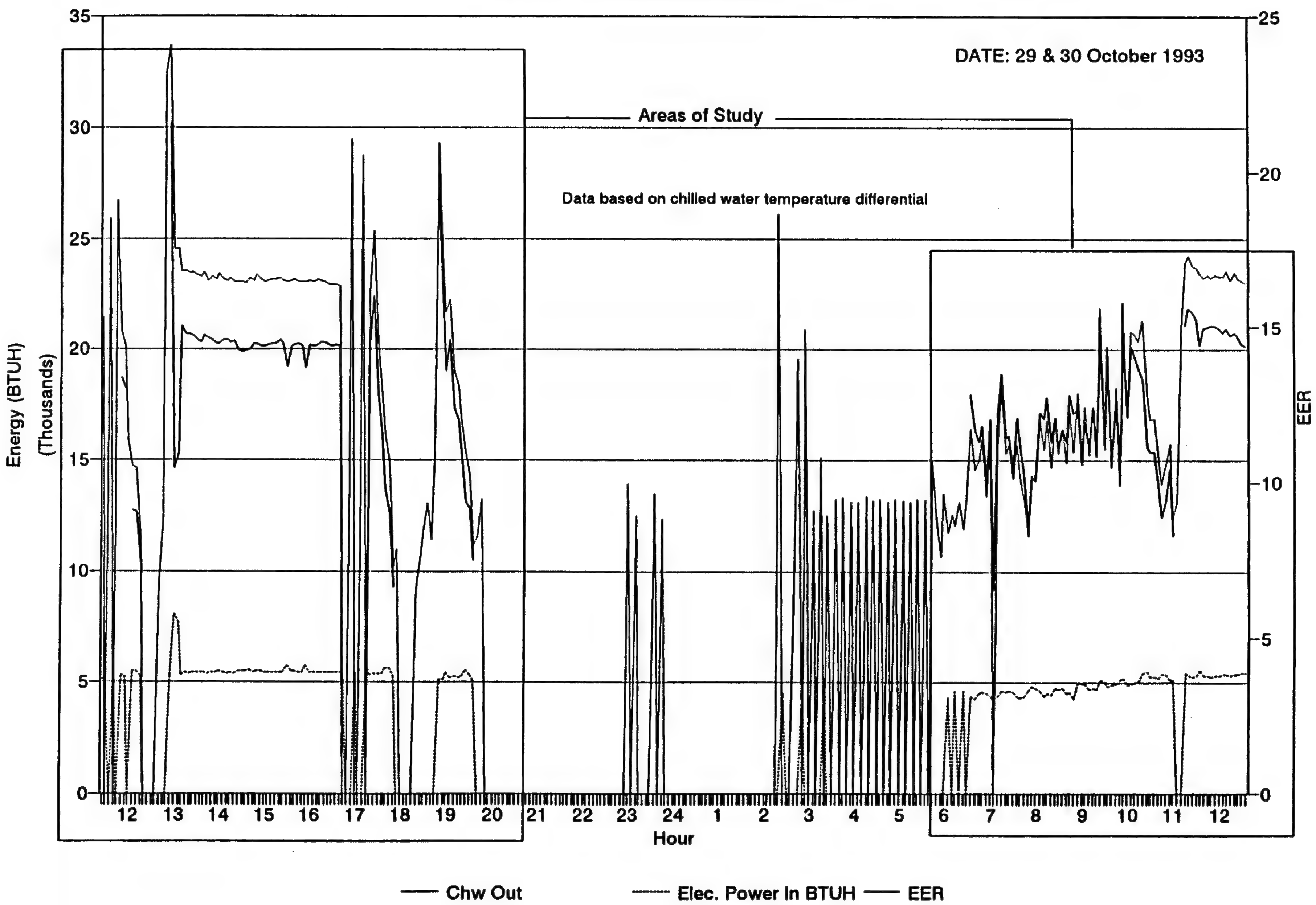


Figure E-2: Building 451 Chiller - EER

55 Ton Carrier 30GB-055-530AA

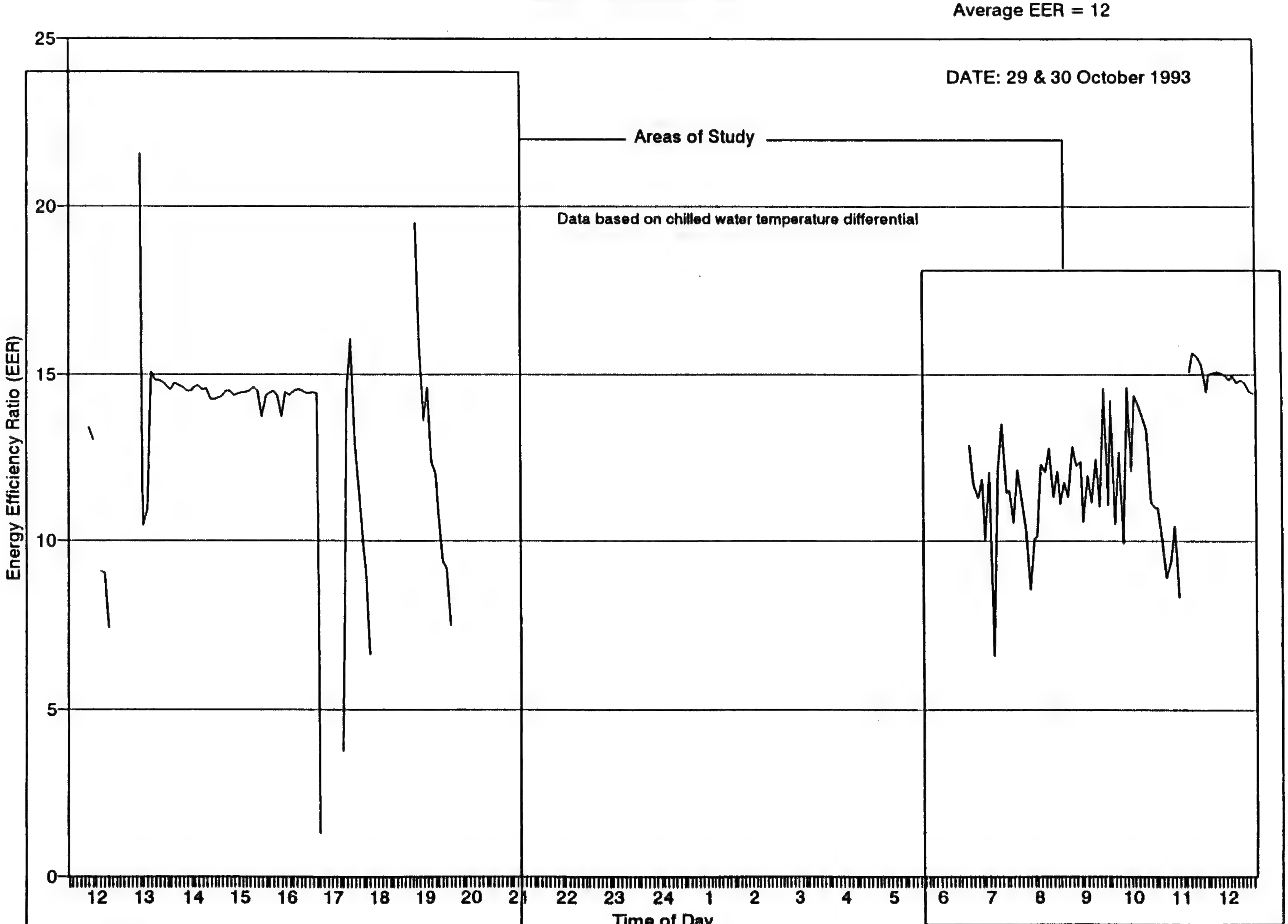


Figure E-3: Building 506 Chiller
220 Ton Trane CVHE-020F-AL-2GB2451DEZA1

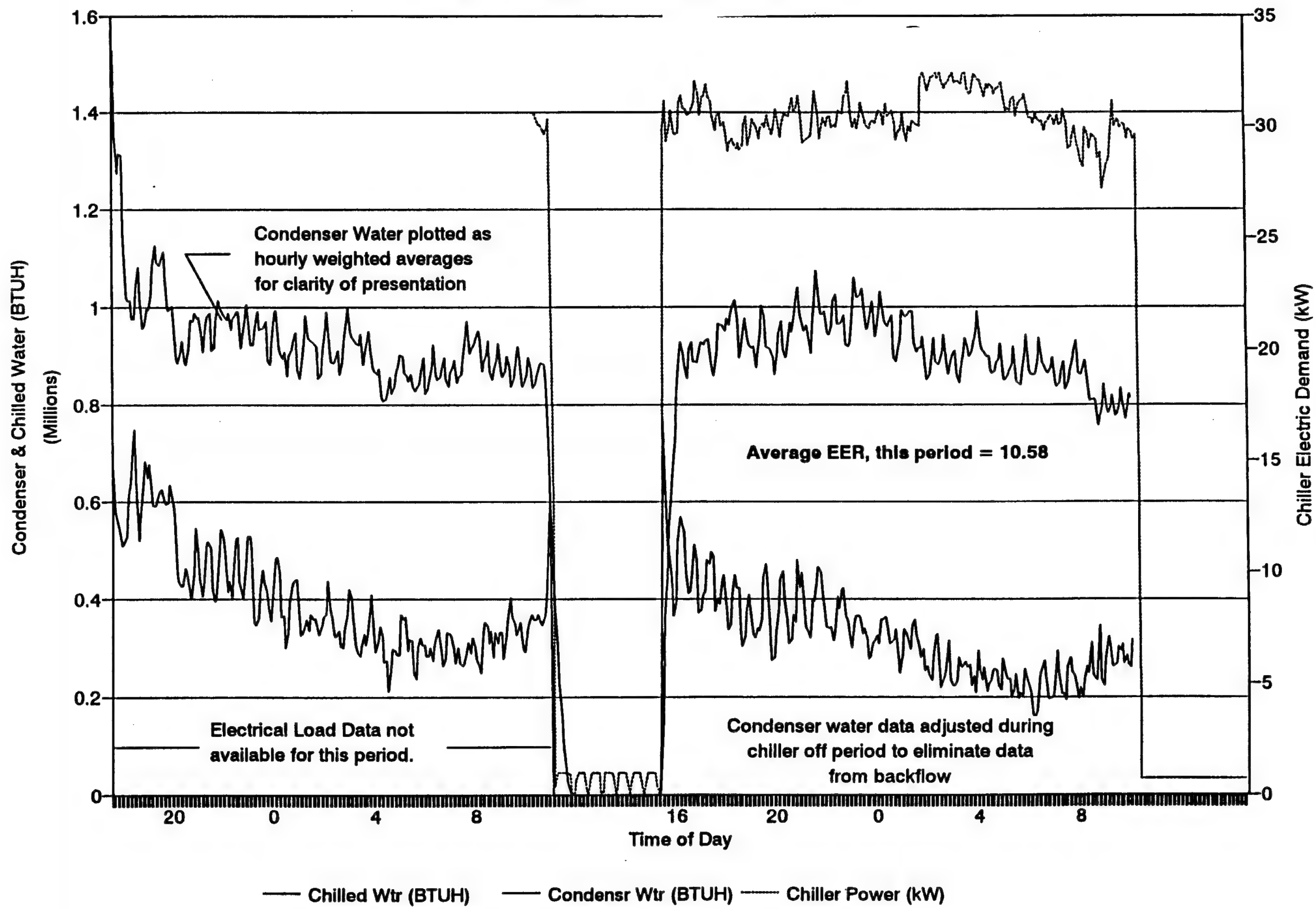


Figure E-4: Building 506 Ice-On-Coil Glycol Chiller

45 Ton Glycol Chiller (Derated from 80 Tons)

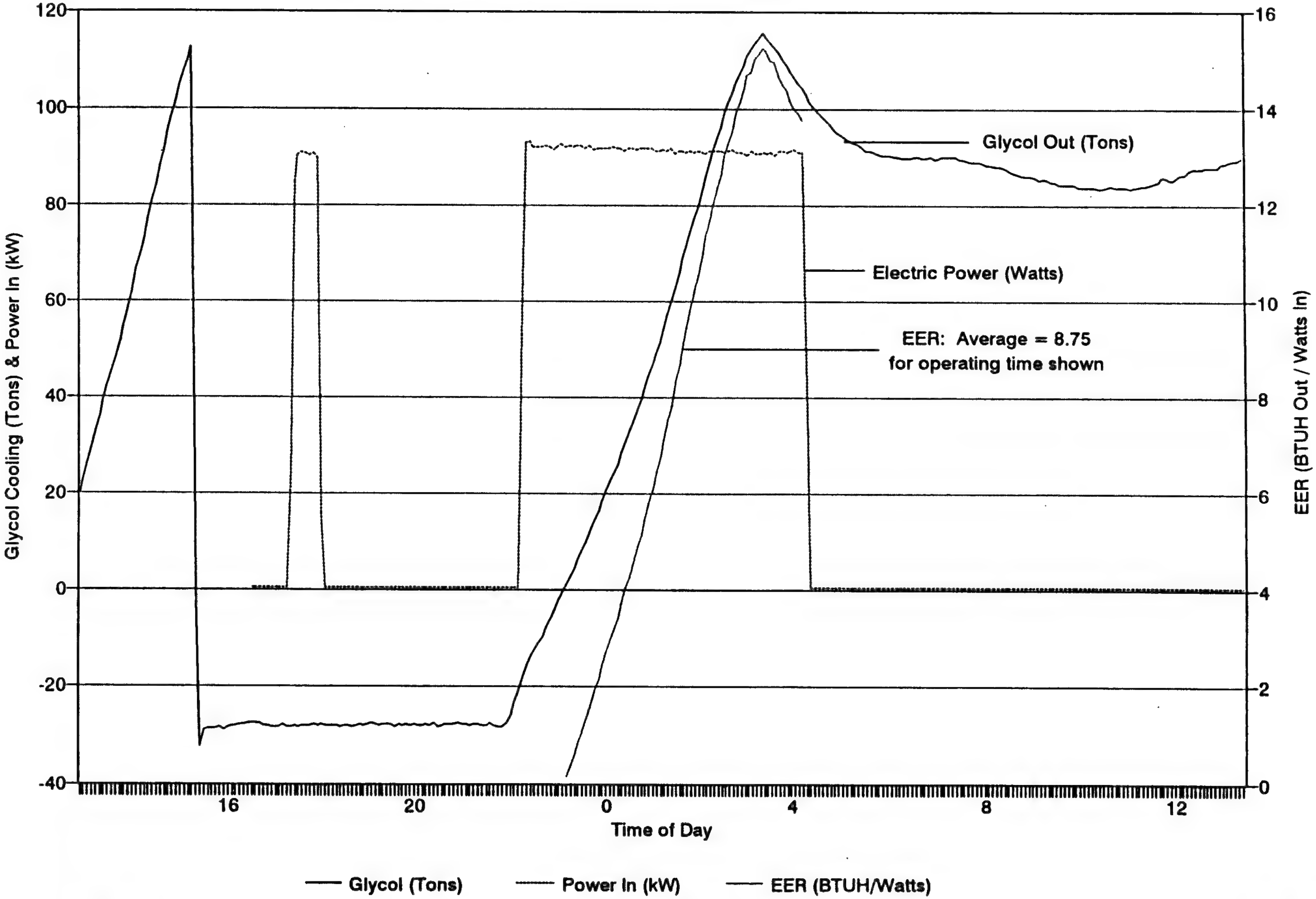


Figure E-5: Building 2105 Chiller No. 1
125 Ton Trane CVHA-011C-HA-06BC

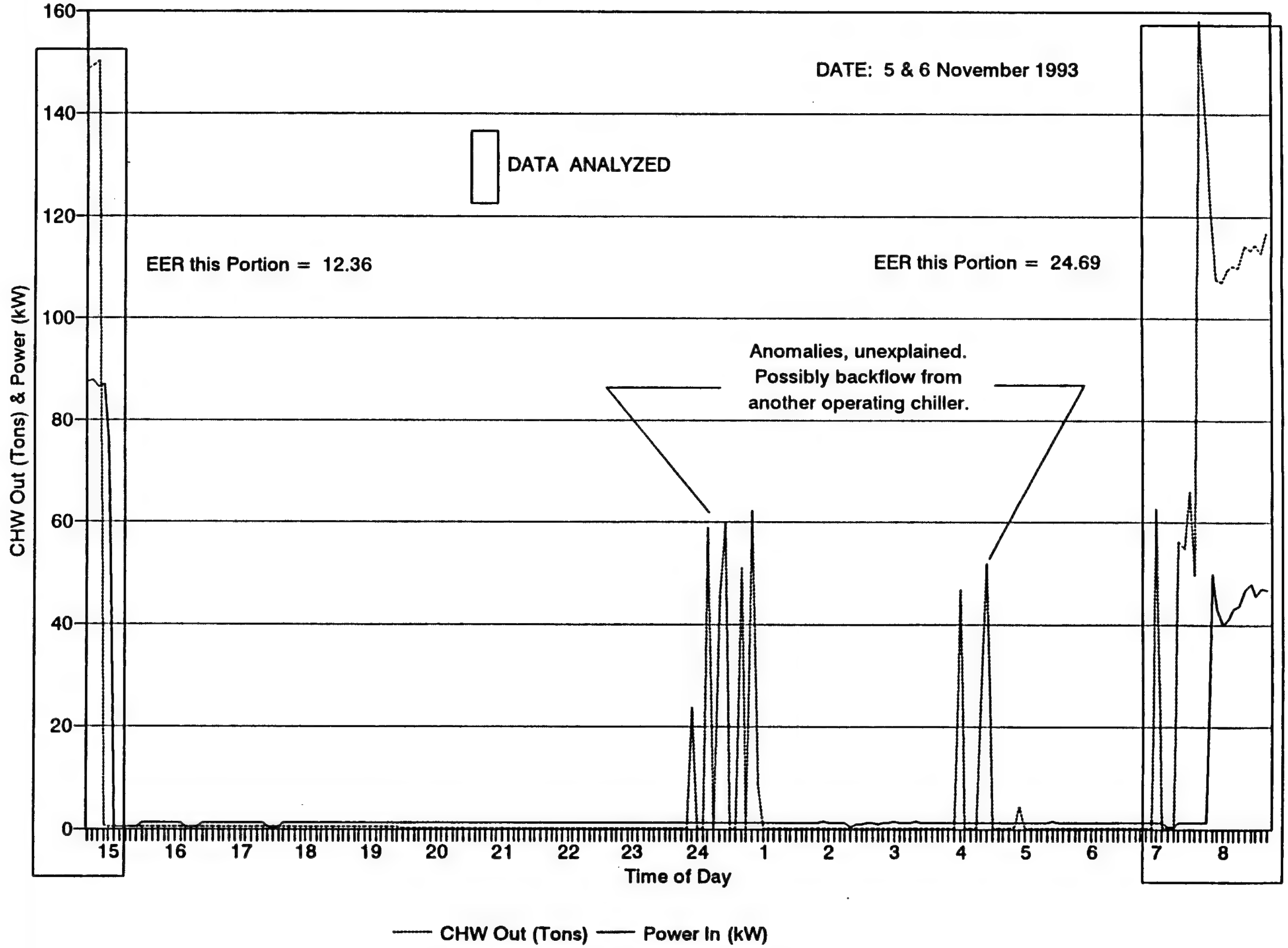


Figure E-6: Building 2105 Chiller No. 2
40 Ton Trane CGWA0404RB51CC5C4B361BE

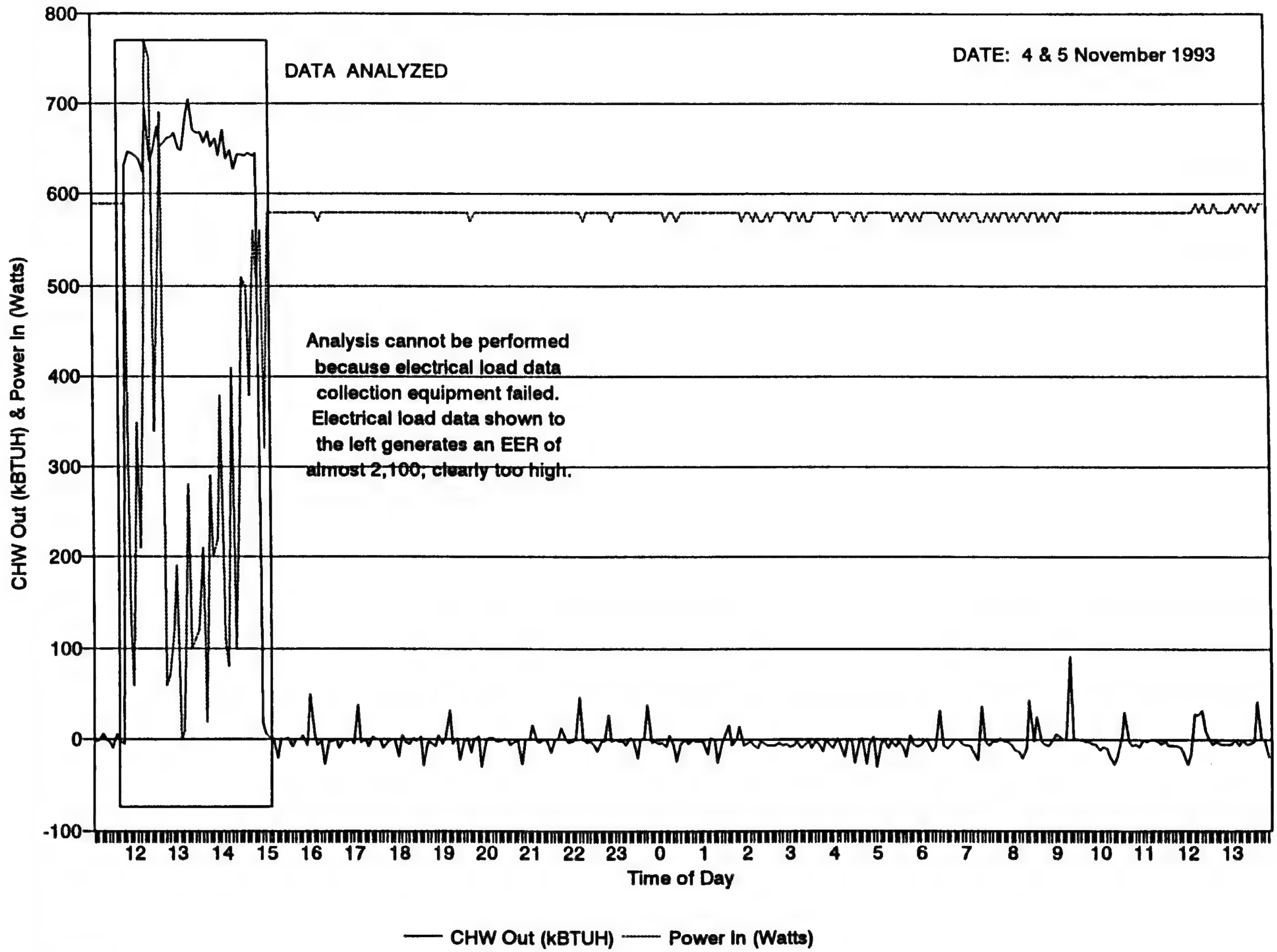


Figure E-7: Building 2105 Chiller No. 5 - Cooling Output vs. Power Input

125 Ton Carrier 19DK4629AE

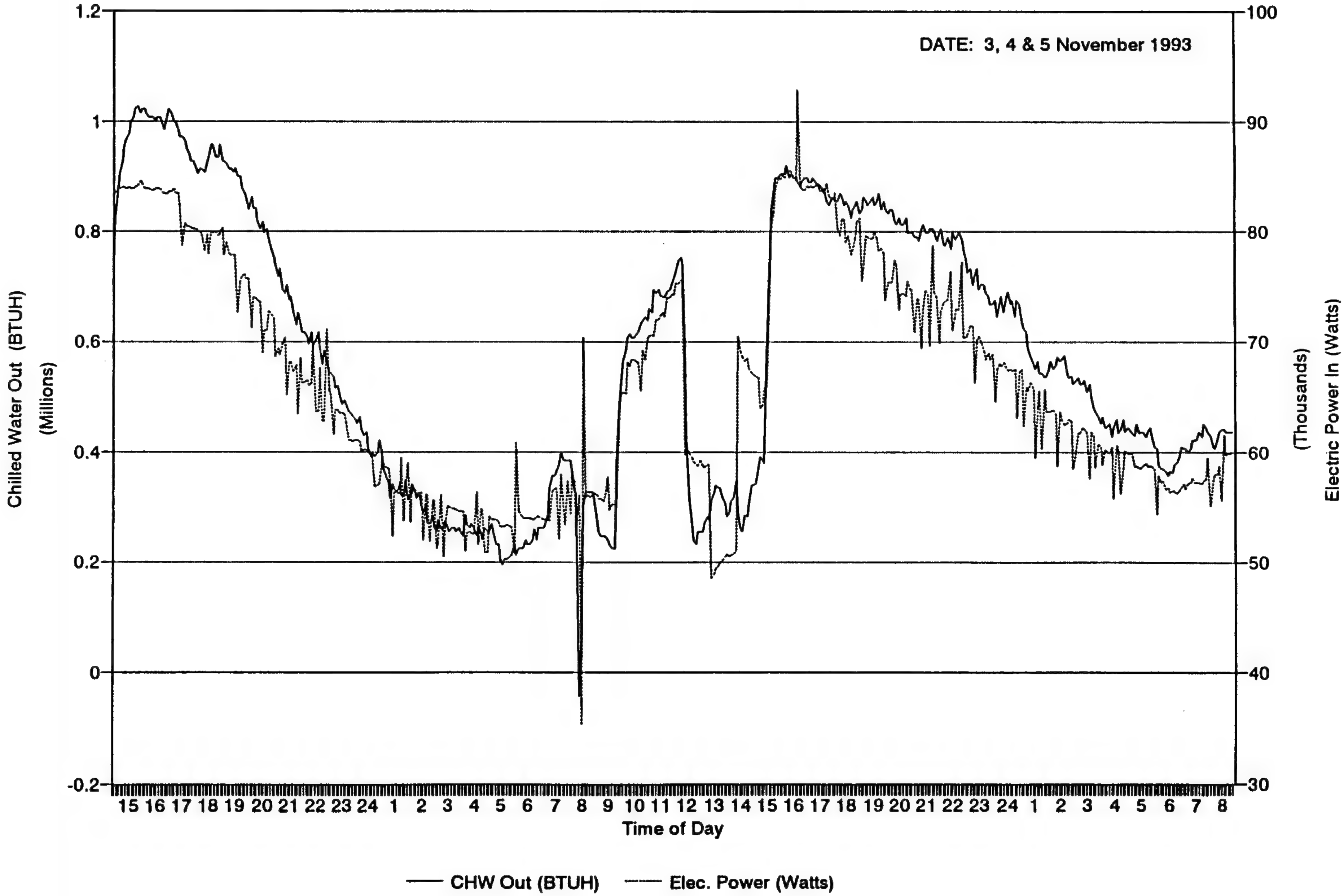


Figure E-8: Building 2105 Chiller No. 5 - EER

125 Ton Carrier 19DK4629AE

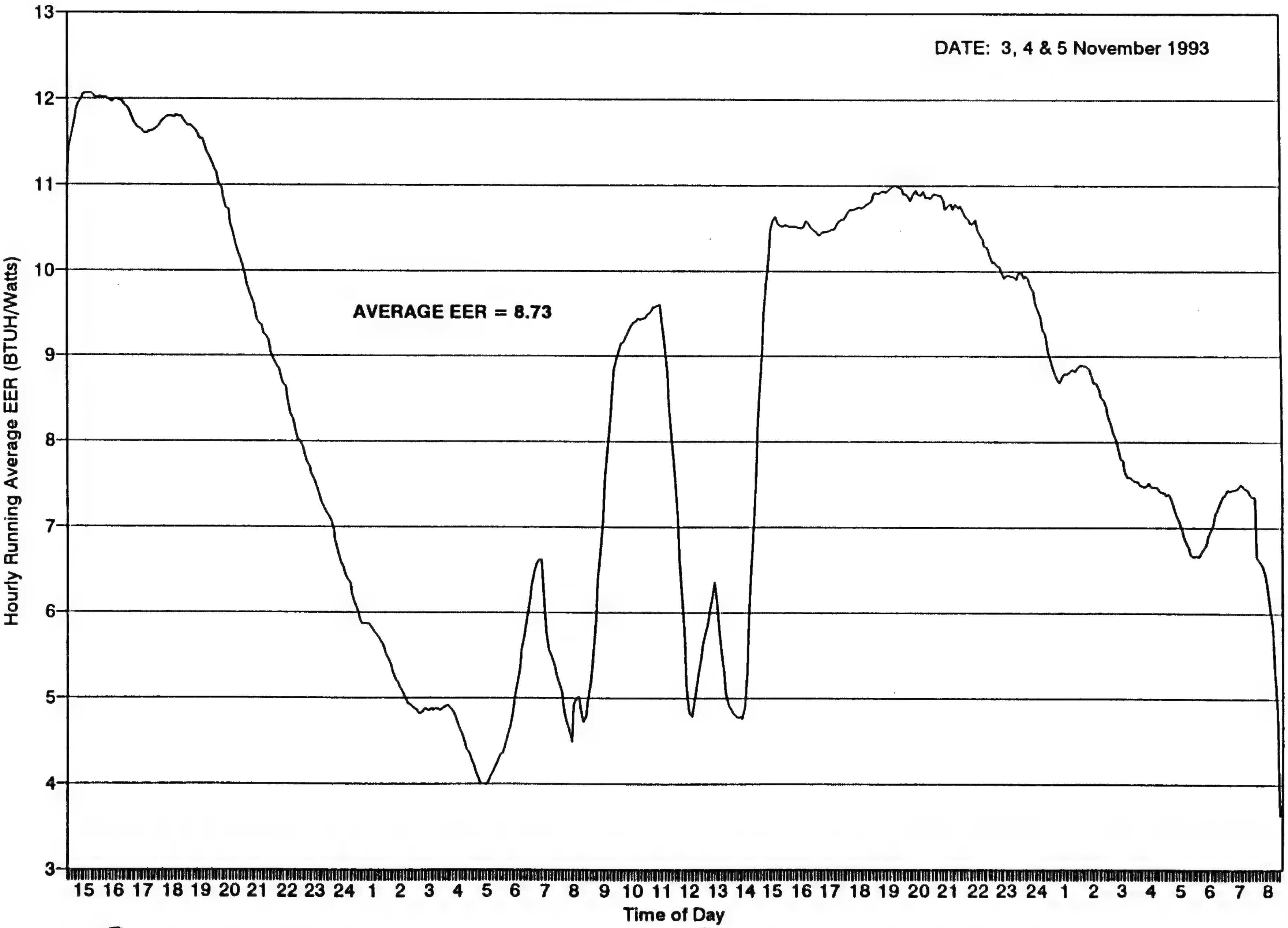


Figure E-9: Building 3482 Direct Expansion Cooling Unit - Cooling Output vs. Power Input

60 Ton Carrier 07LB081-A269

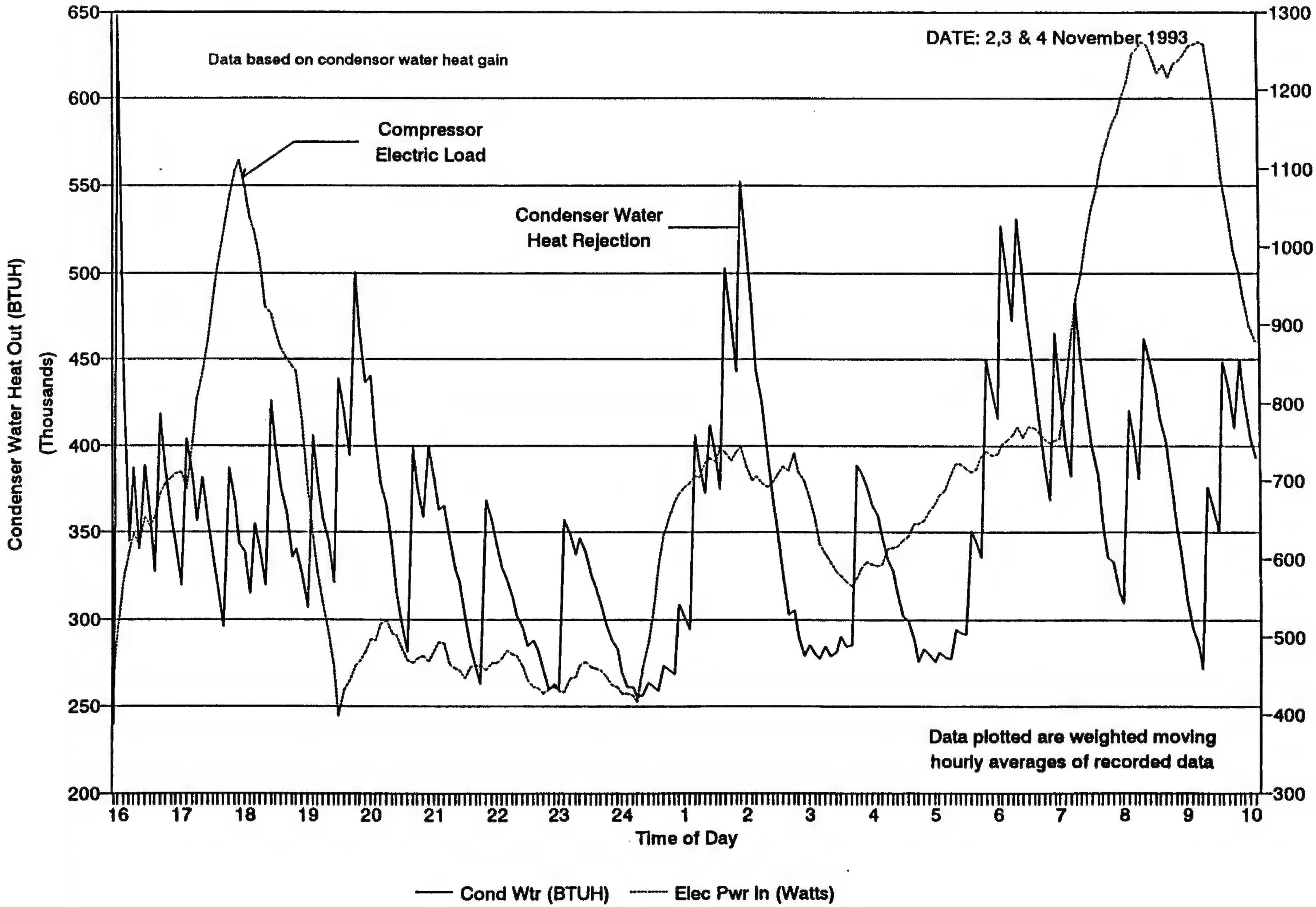


Figure E-10: Building 3482 Direct Expansion Cooling Unit - EER
60 Ton Carrier 07LB081-A269

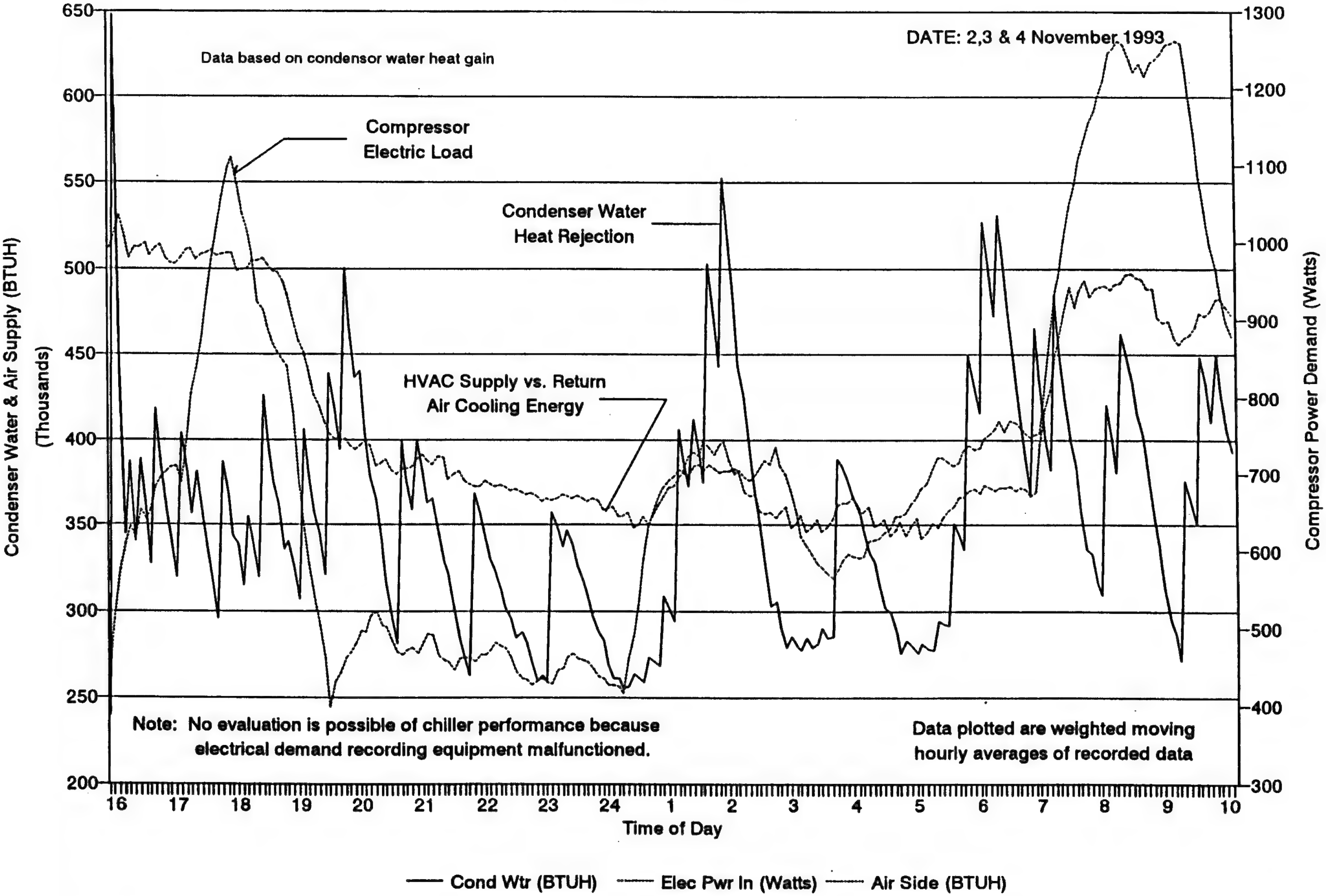


Figure E-11: Building 3490 Chiller No. 1 - Cooling Output vs. Power Input

25 Ton Air-Cooled Reciprocating Chiller

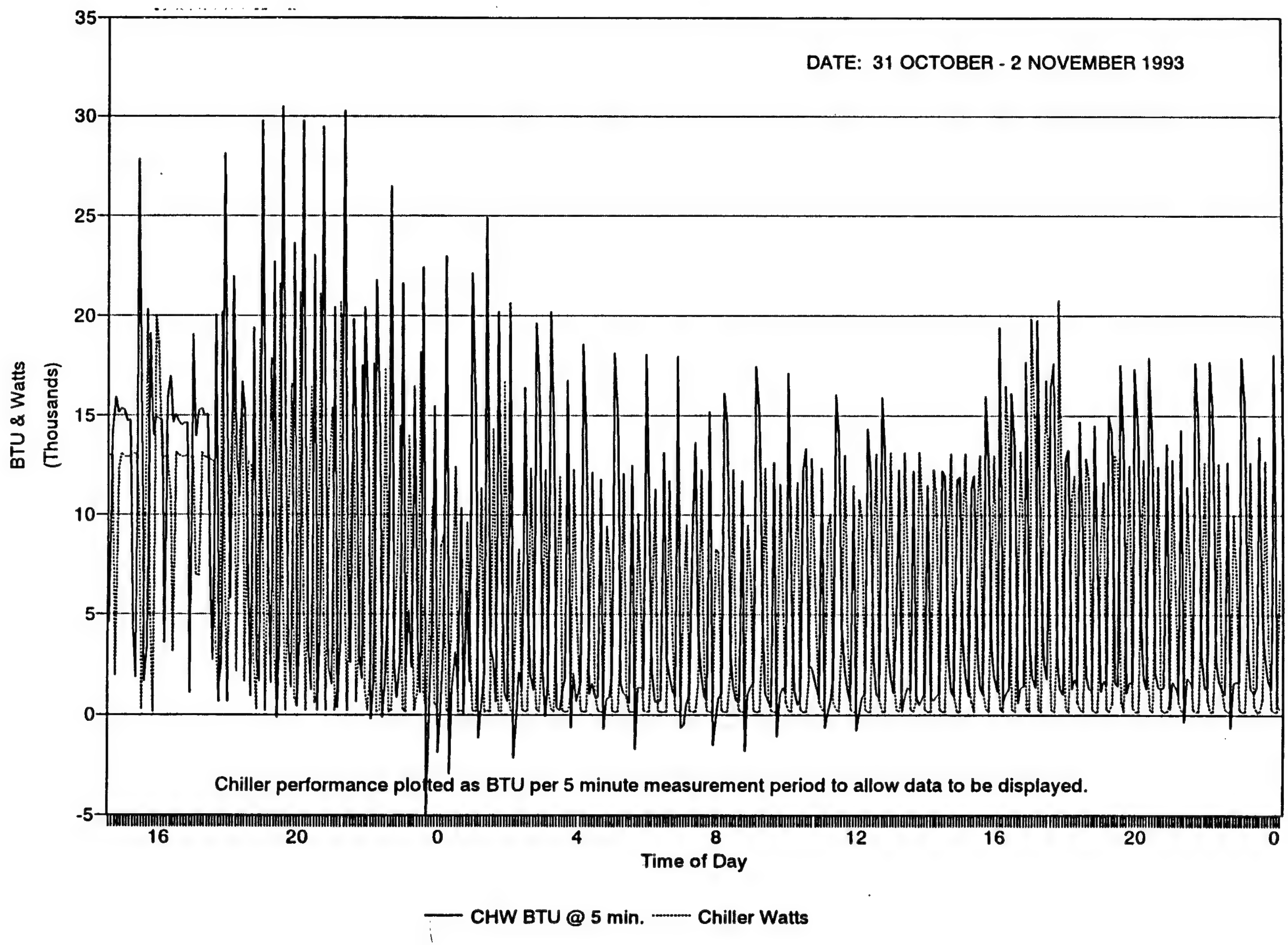


Figure E-12: Building 3490 Chiller No. 1 - EER

25 Ton Air-Cooled Reciprocating Chiller

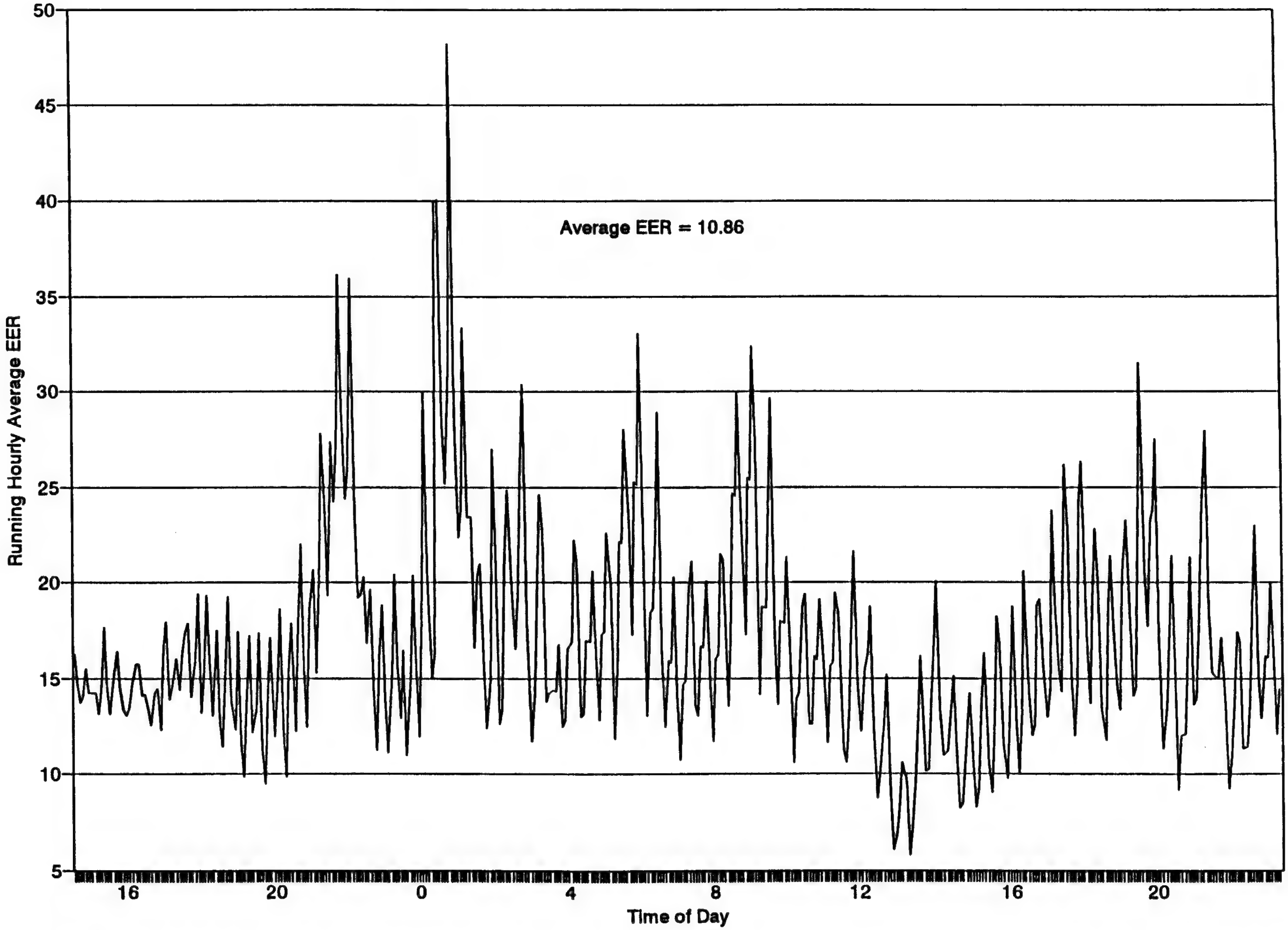


Figure E-13: Building 3490 Chiller No. 2 - Cooling Output vs. Power Input

50 Ton Air-Cooled Reciprocating Chiller

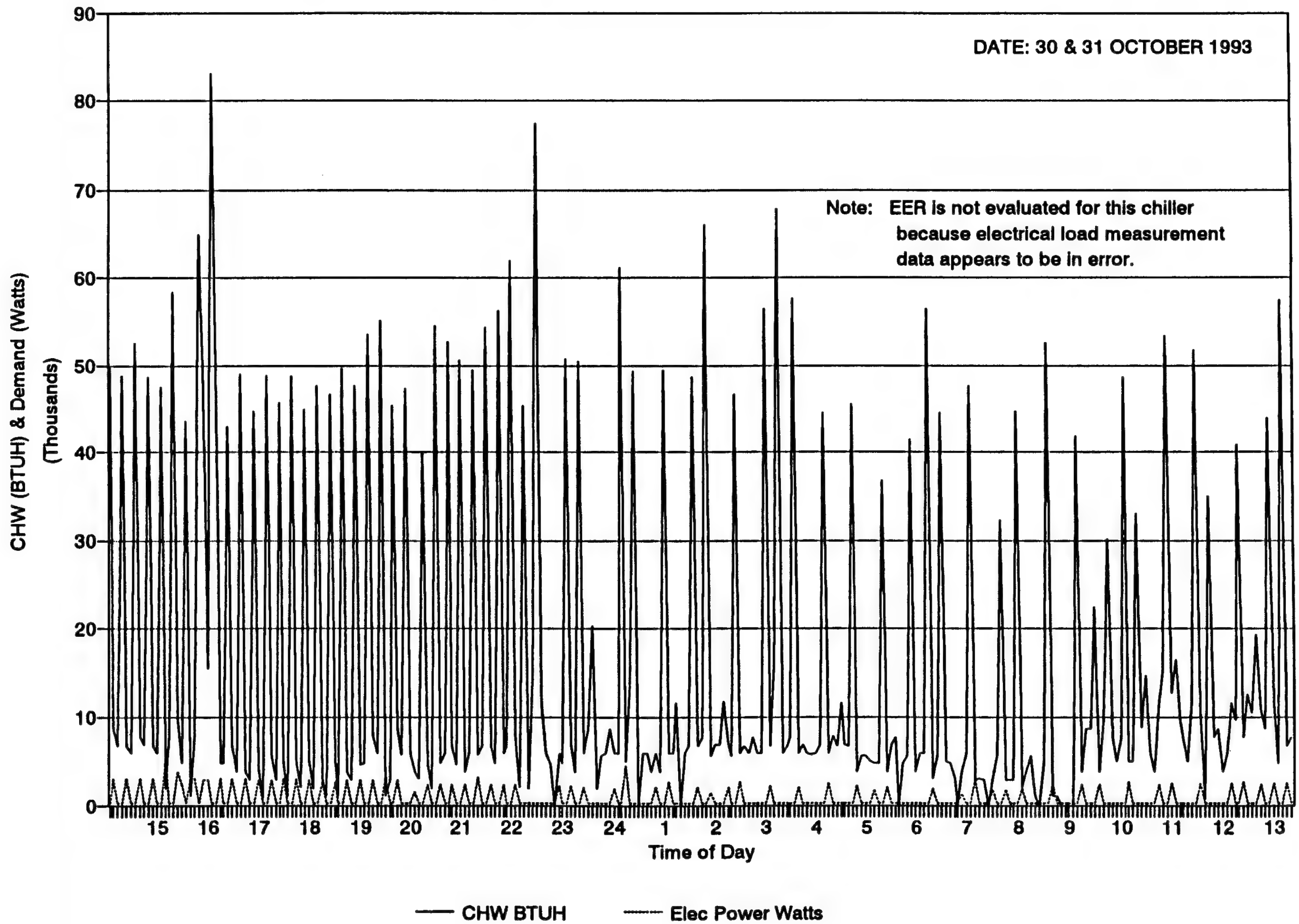


Figure E-14 Building 3490 Chiller No. 2 (First Half) - Cooling Output vs. Power Input

50 Ton Air-Cooled Reciprocating Chiller

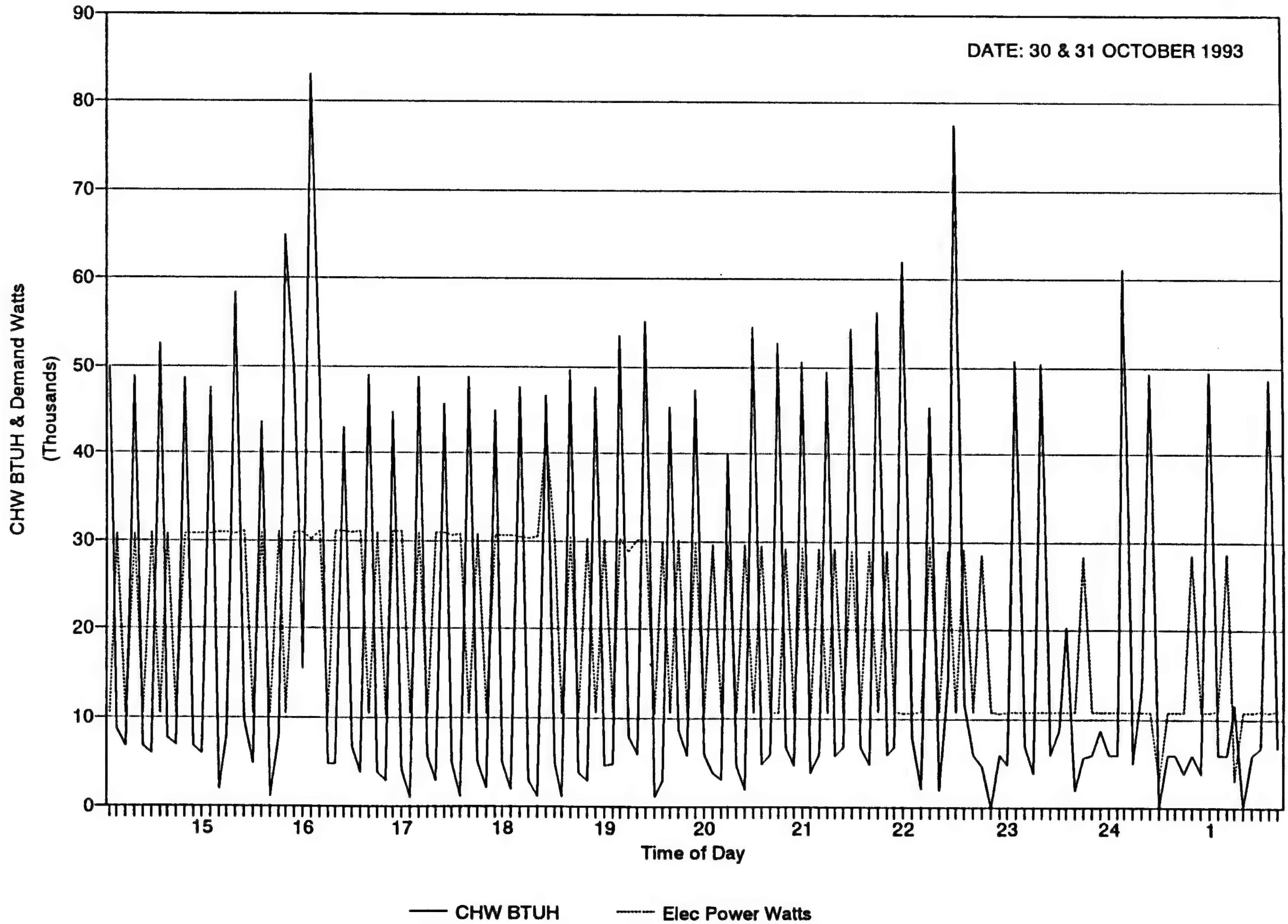


Figure E-15 Building 3490 Chiller No. 2 (Second Half) - Cooling Output vs. Power Input

50 Ton Air-Cooled Reciprocating Chiller

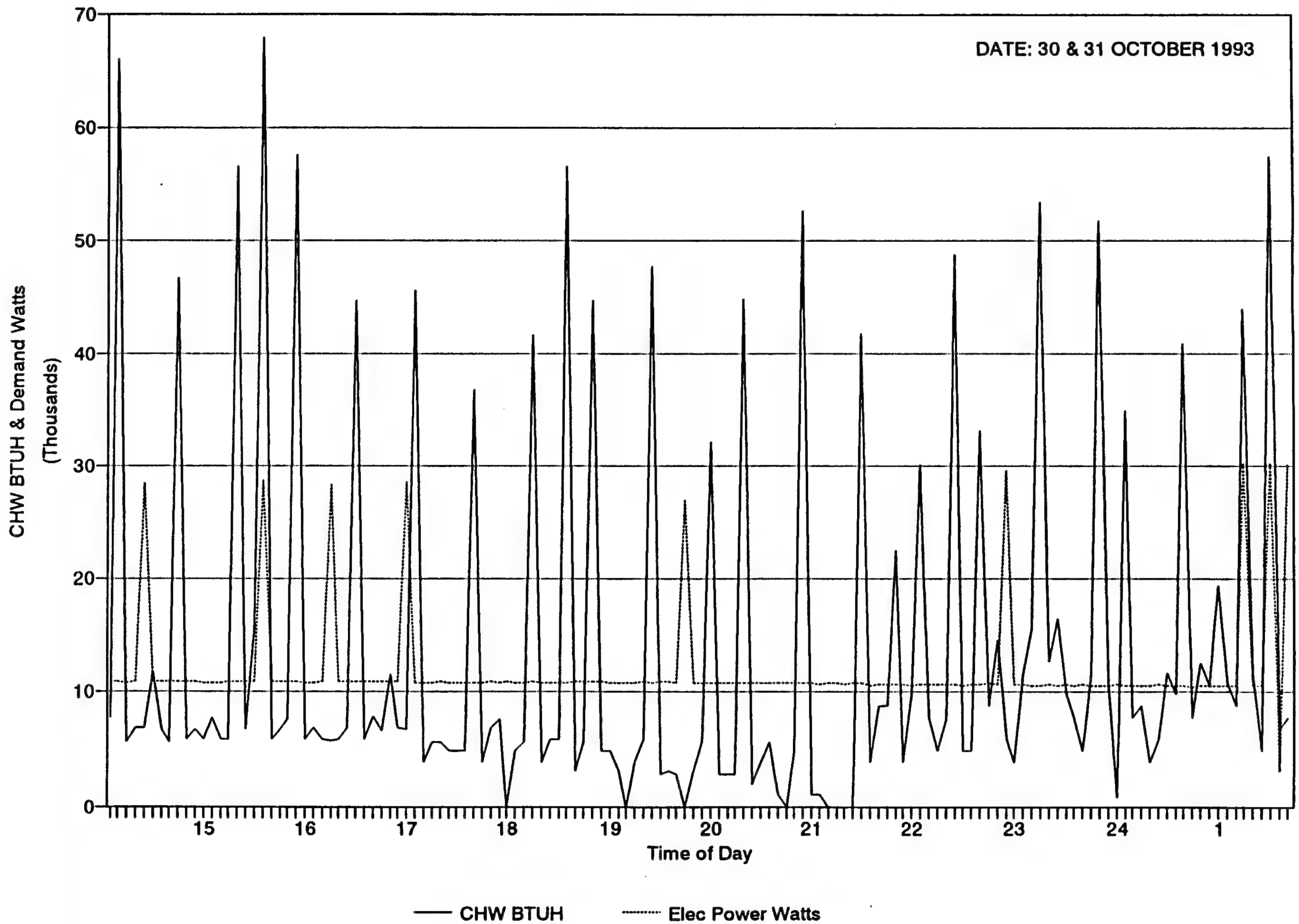


Figure E-16: Building 3490 Chiller No. 2 - EER

50 Ton Air-Cooled Reciprocating Chiller

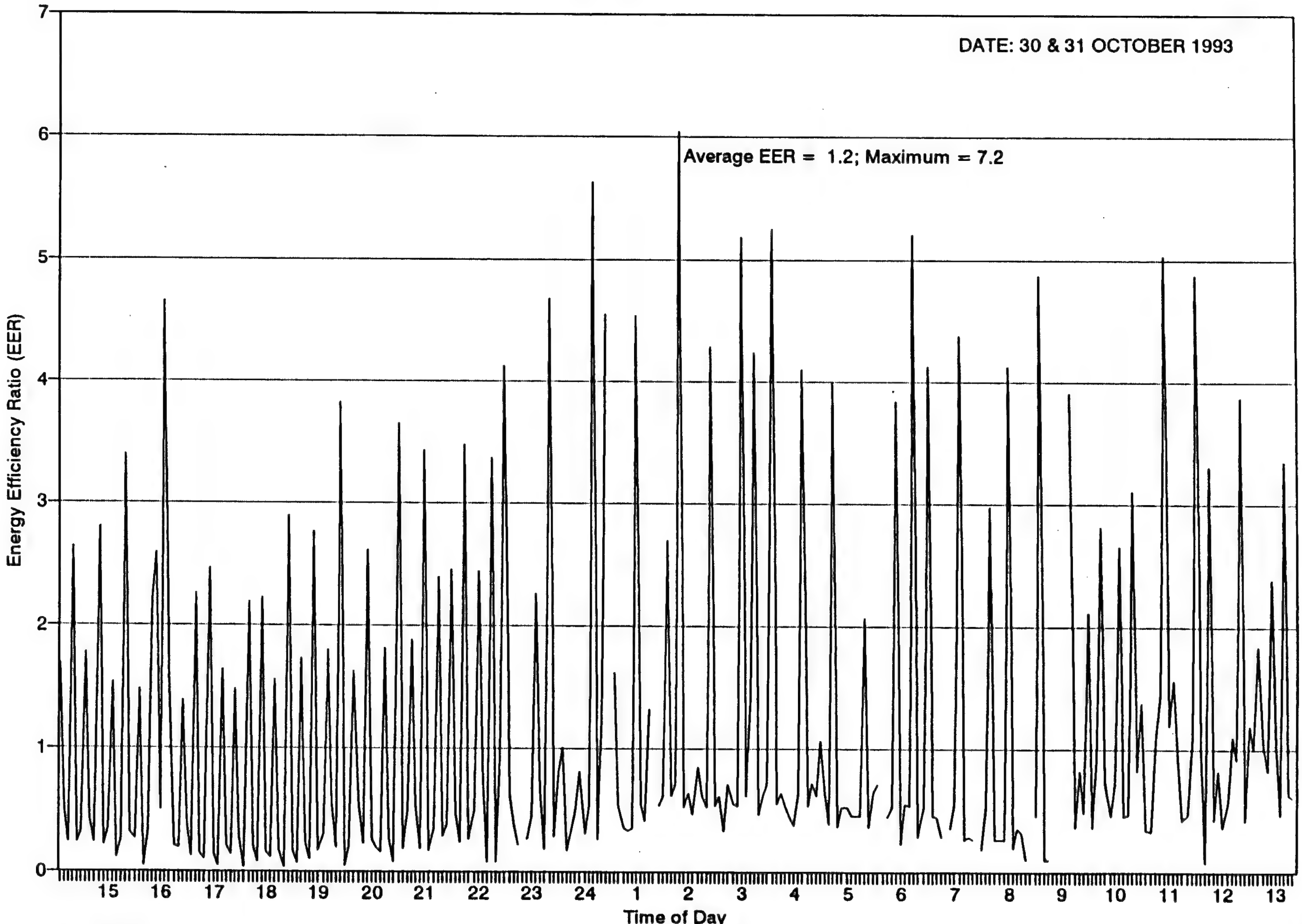


Figure E-17 Building 3490 Chiller No. 3 - Cooling Output vs. Power Input

100 Ton Air-Cooled Reciprocating Chiller

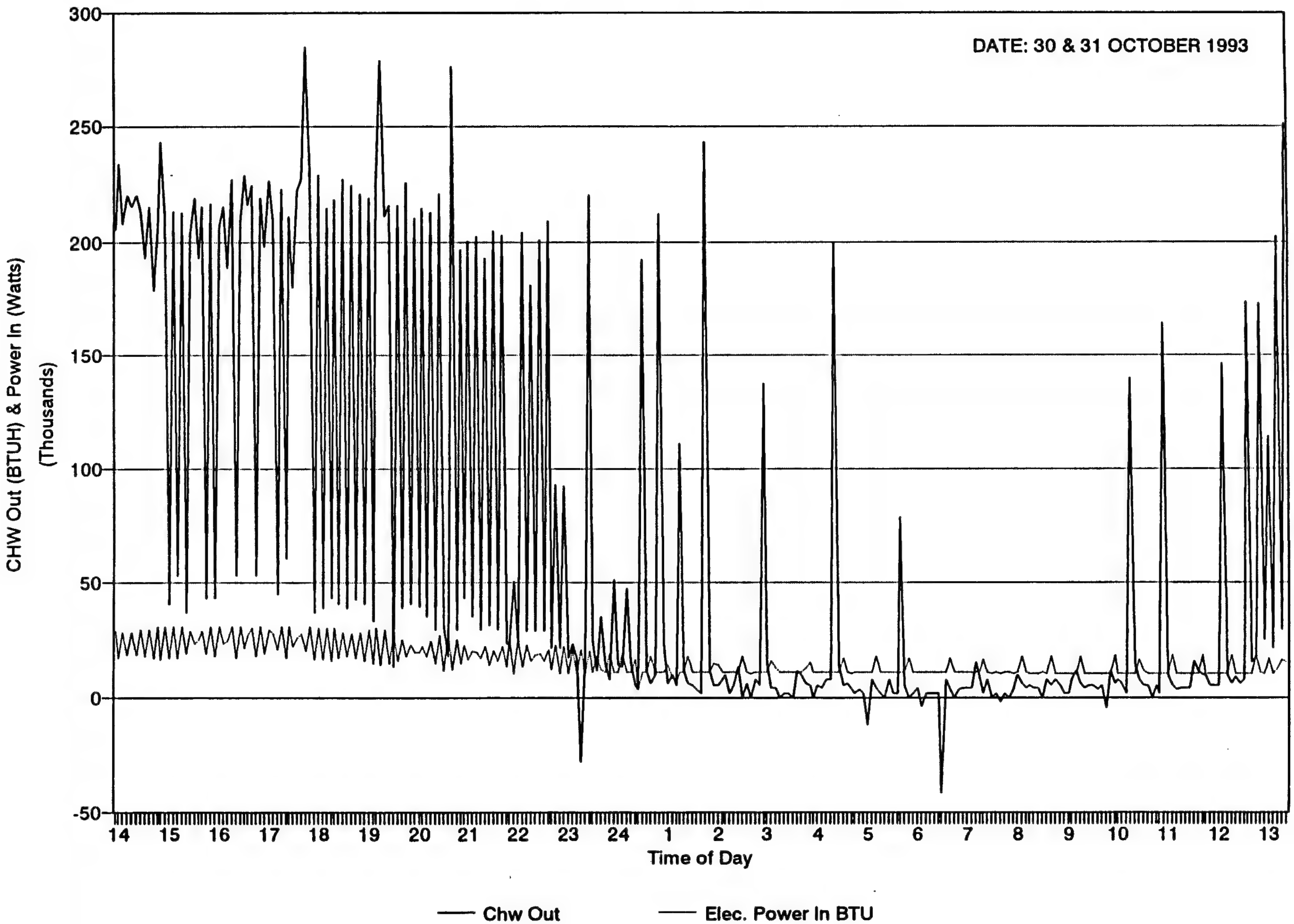


Figure E-18: Building 3490 Chiller No. 3 - EER

100 Ton Air-Cooled Reciprocating Chiller

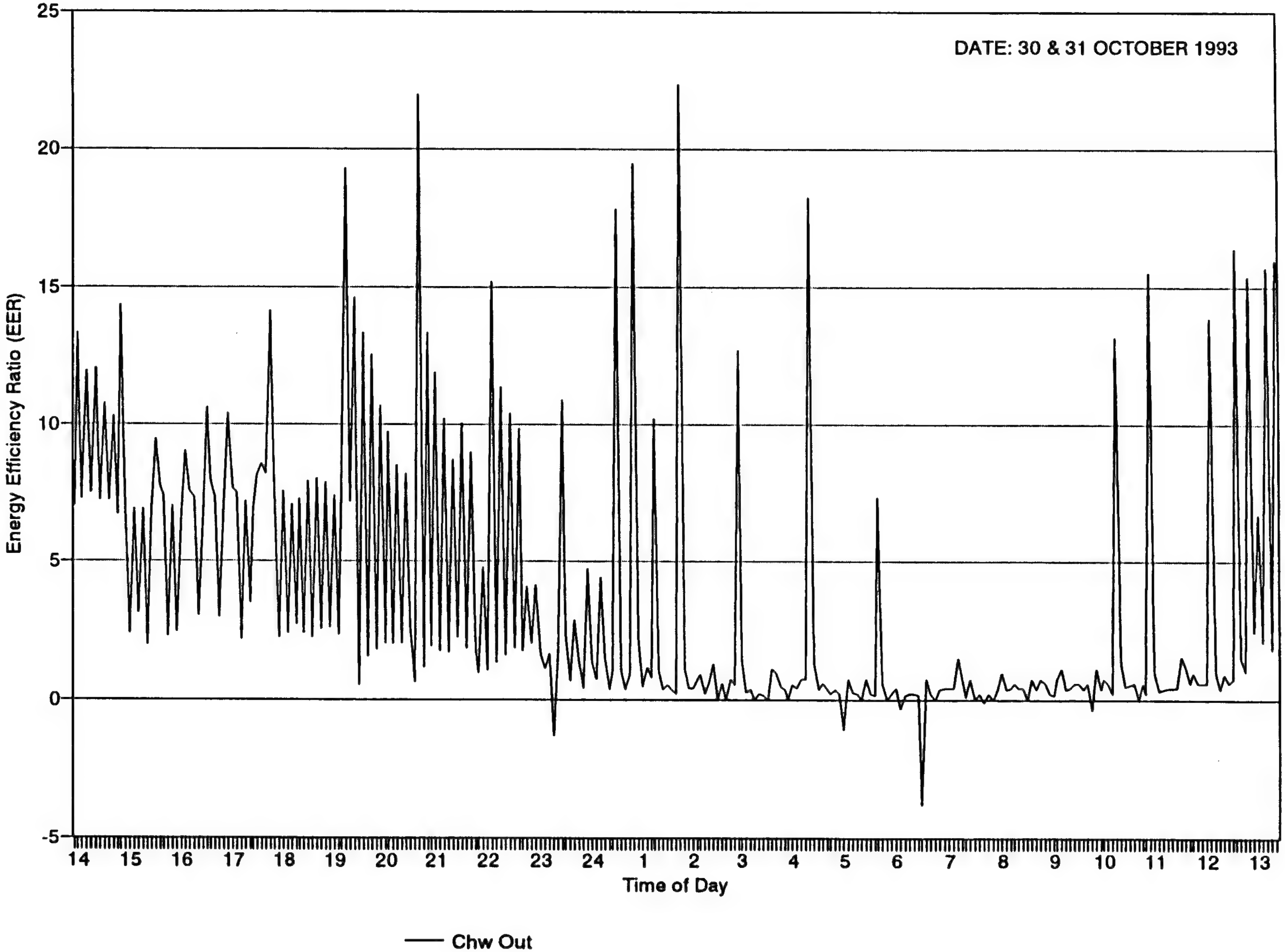


Figure E-19: Building 3490 Chiller No. 3 - Hourly Average EER

100 Ton Air-Cooled Reciprocating Chiller

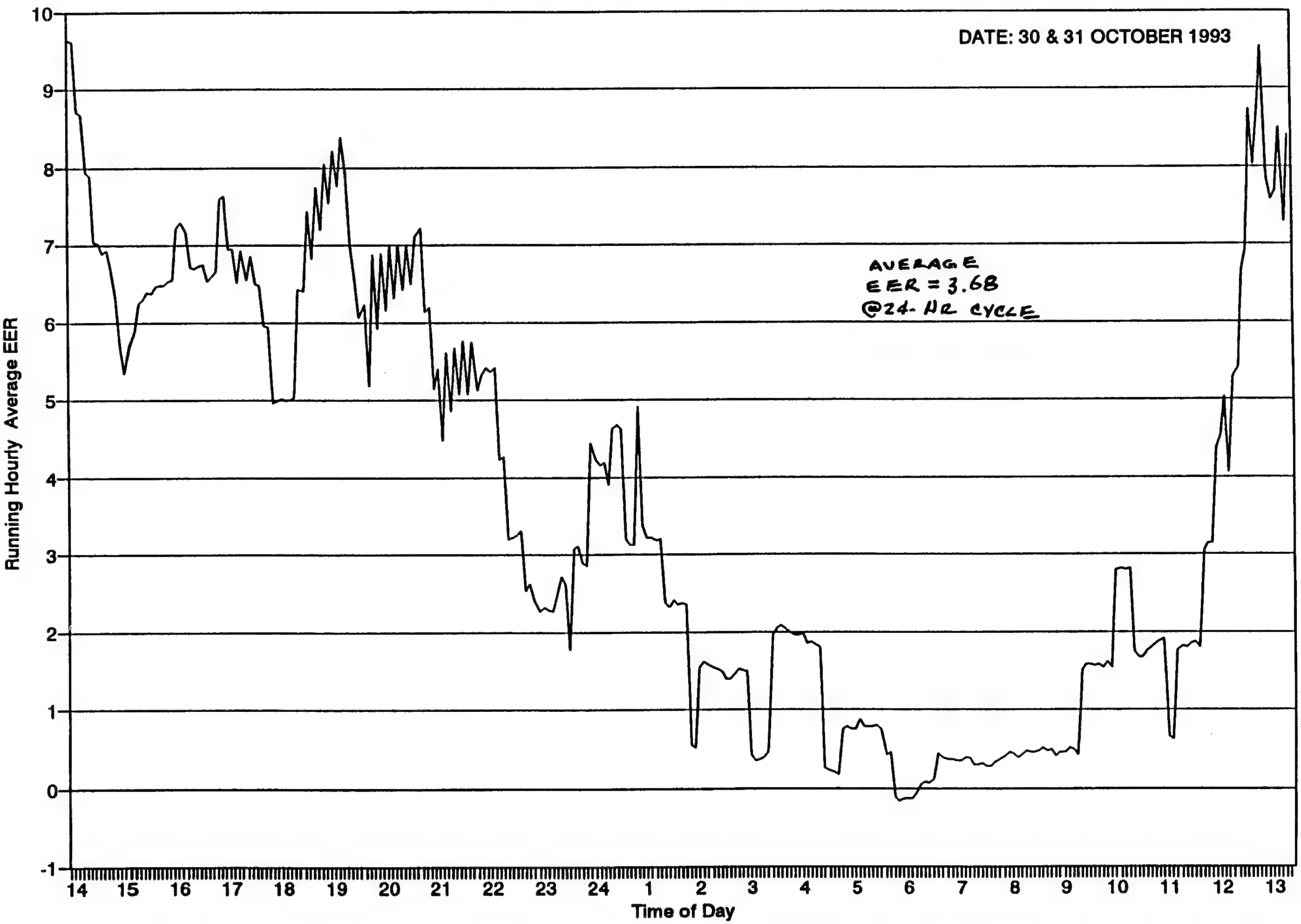


Figure E-20: Building 3510 Direct Expansion Cooling Unit - Hourly Average Operating Data

Trane RWUA0481EB51FC5C4L361BEJ

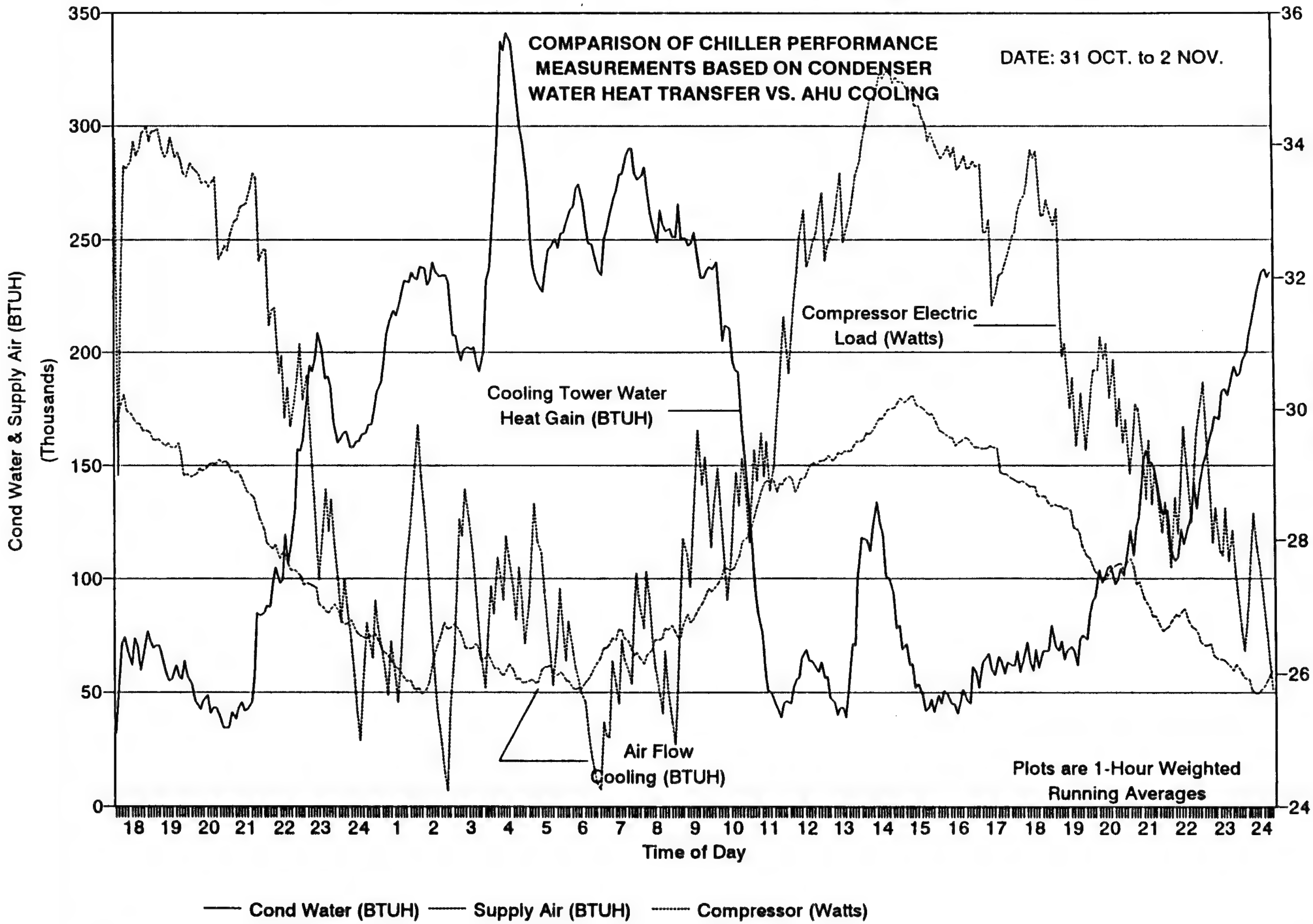


Figure E-21: Building 3510 Direct Expansion Cooling Unit - Operating Data (5 Minute Intervals)

Trane RWUA0481EB51FC5C4L361BEJ

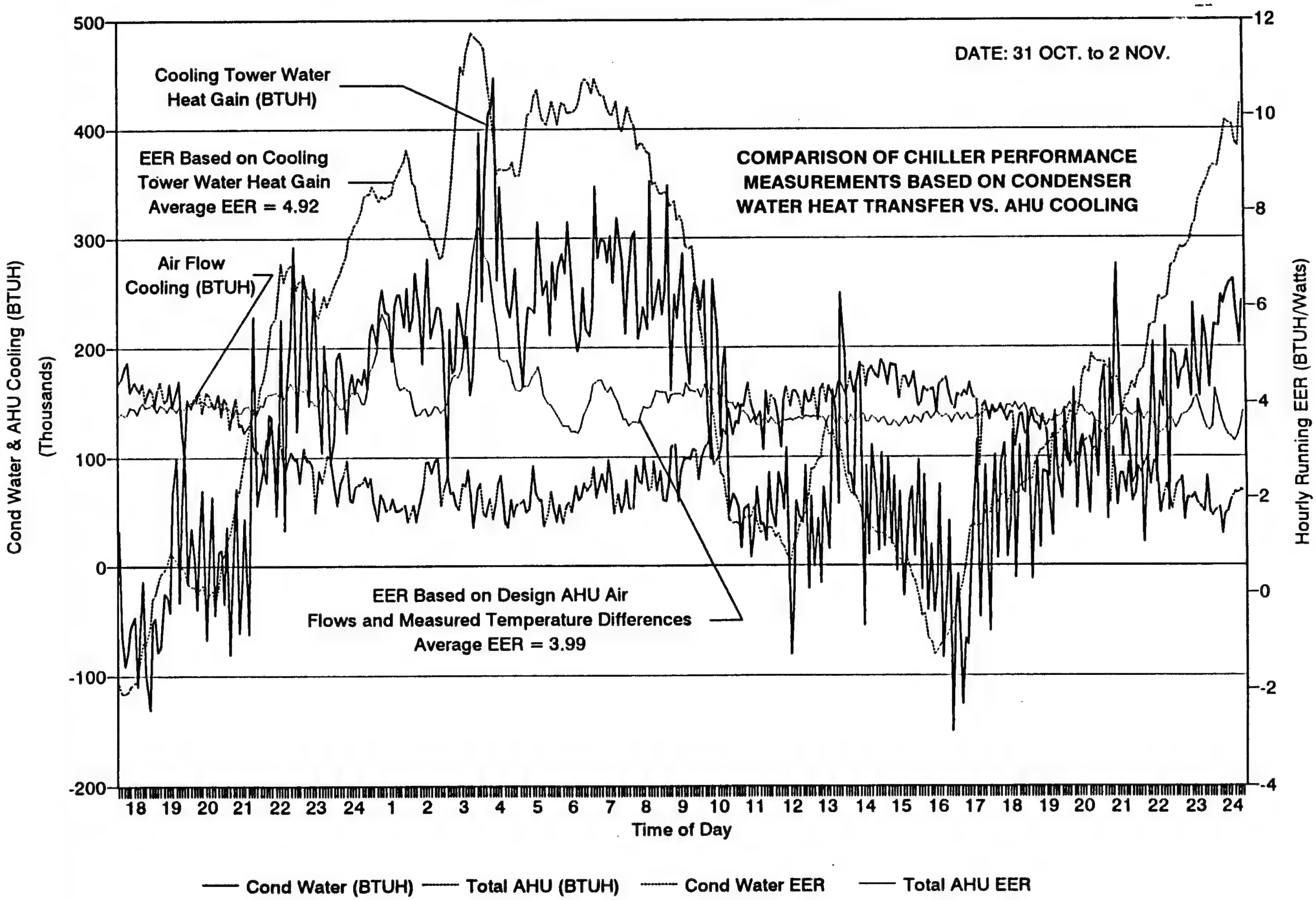


Figure E-22: Building 3510 Direct Expansion Cooling Unit - Comparison of EER's

Trane RWUA0481EB51FC5C4L361BEJ

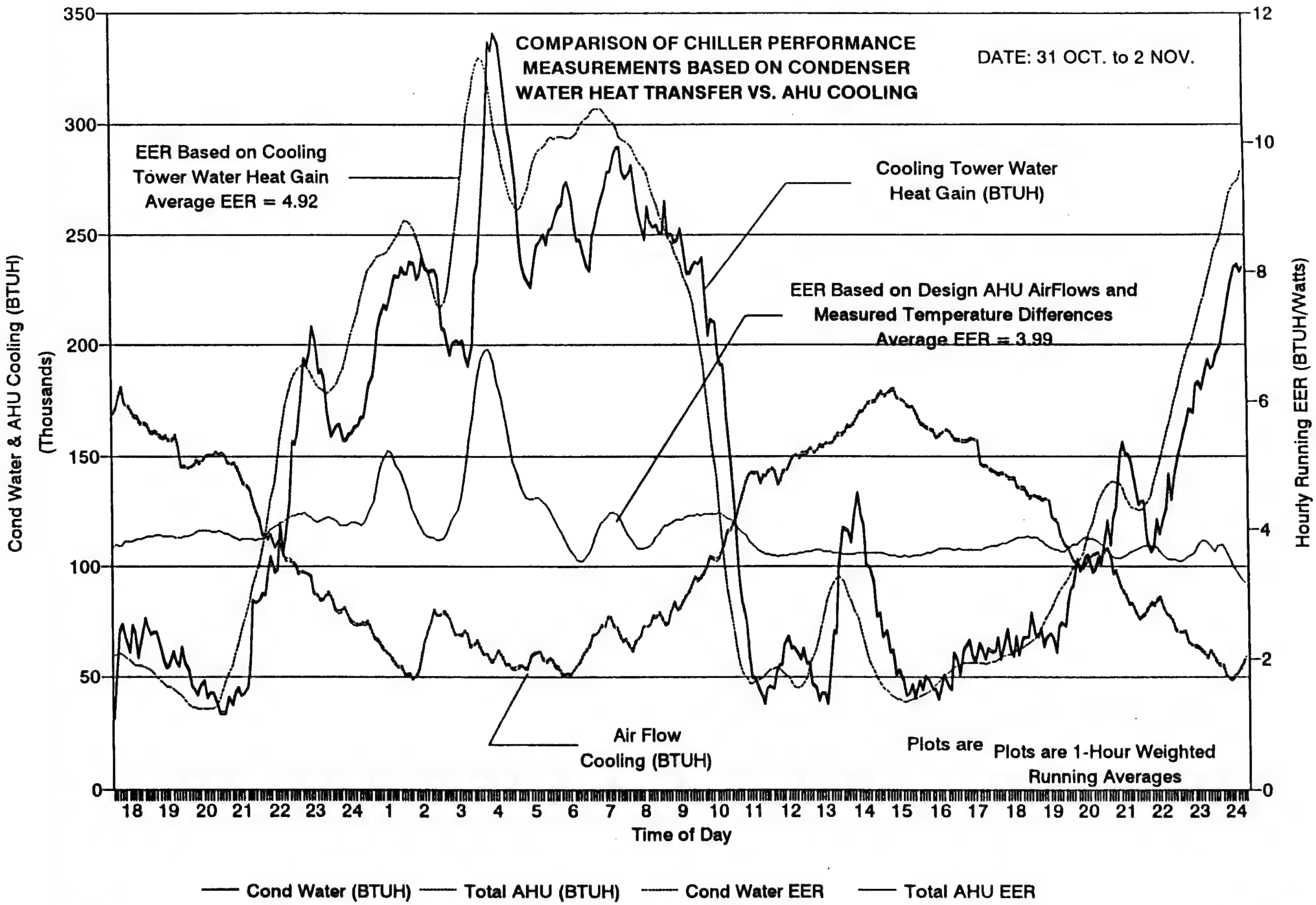
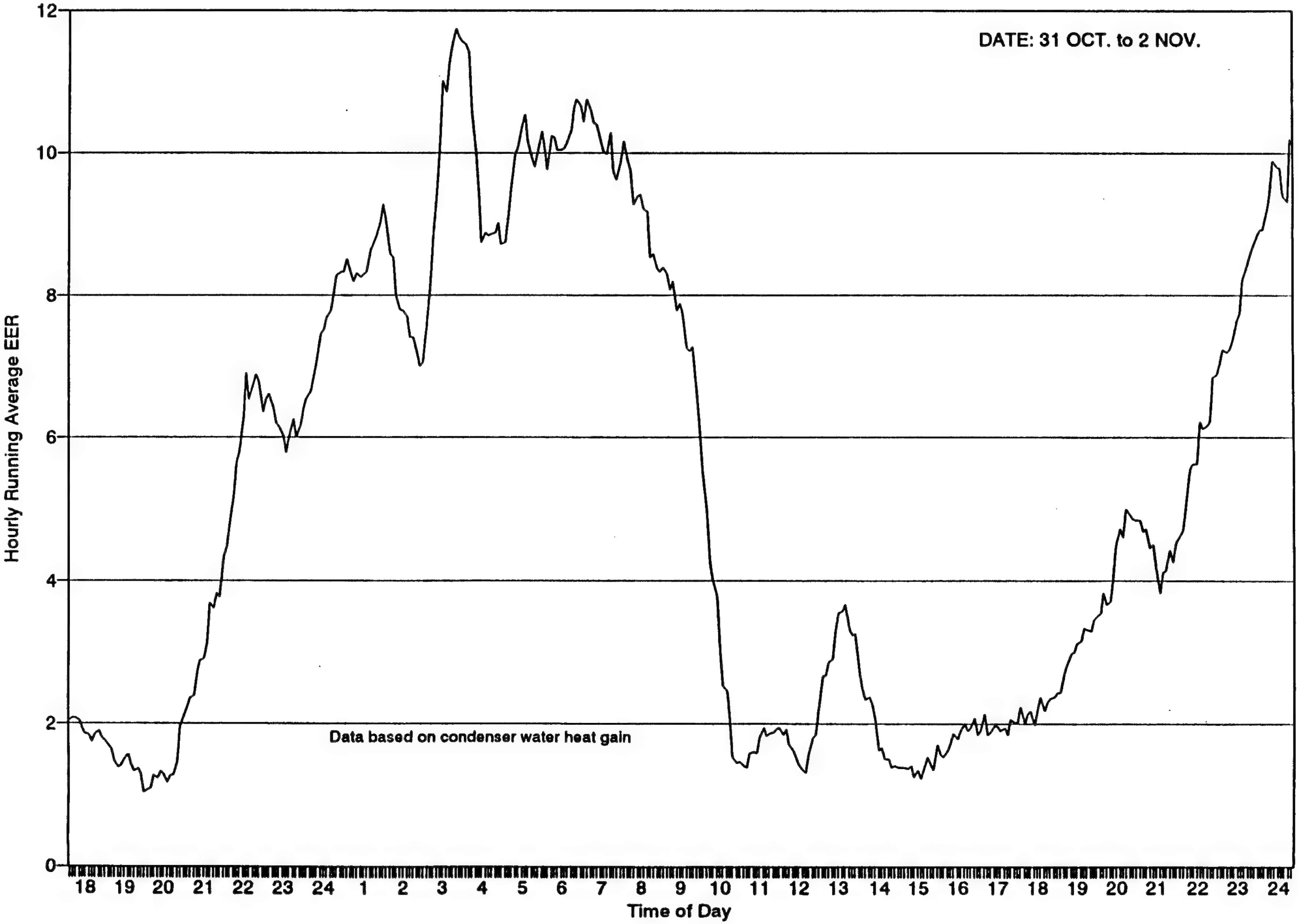


Figure E-23: Building 3510 Direct Expansion Cooling Unit - Hourly Average EER

Trane RWUA0481EB51FC5C4L361BEJ



Appendix F

Chiller Retrofit Calculations

APPENDIX F

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Summary: Refrigerant Compliance & Energy Conservation Analyses

Refrigerant Compliance

Each of the chillers included in this study is evaluated and measures are developed to achieve compliance with the Montreal Protocol. Options considered include:

- Continue using and **contain** existing refrigerants until unit is to be replaced.
- Retrofit unit for **conversion** of refrigerant to a non-CFC refrigerant.
- **Replace** unit with one built for an HFC refrigerant (not regulated by the Montreal Protocol).

Refrigerant containment equipment retrofits are recommended for:

Building	451	55 Ton A/C Reciprocating Chiller
Building	2105 C5	125 Ton W/C Centrifugal Chiller
Building	3490 C1	25 Ton A/C Reciprocating Chiller
Building	3490 C2	50 Ton A/C Reciprocating Chiller
Building	3490 C3	100 Ton A/C Reciprocating Chiller
Building	3510	40 Ton W/C Reciprocating DX Unit

Refrigerant replacement projects are recommended for none of the study chillers at this time.

Chiller replacements are recommended for the following:

Building	506 C1	220 Ton W/C Centrifugal Chiller
Building	506 C2	45 Ton A/C Reciprocating Glycol Chiller
Building	2105 C1	125 Ton W/C Centrifugal Chiller
Building	2105 C2	40 Ton W/C Reciprocating Chiller

Note: The glycol chiller serving the Ice-On-Coil system of building 506 was evaluated for replacement as an energy conservation retrofit and was found to be economically justified.

Analysis results are summarized on Refrigeration Plan Section, Table 2.

Energy Conservation Opportunity Analyses

Energy conservation opportunities considered for chillers included in this study consist of the following evaluations:

- Chilled Water Temperature Reset
- Evaporative Precooling of Air-Cooled Condenser Cooling Air
- Duty Cycling Controls
- Optimal Cooling Tower Control
- Electronic Expansion Valve Retrofits on DX Cooling Units
- Manifolding Building 3490 Chillers

Analysis results are summarized on Table 1.

Table 1: Summary of Cooling Equipment Energy Conservation Opportunity Evaluations

Project Description	Electric Savings	Energy Cost Saved		O&M Cost Savings		Investment	Economic Measures		
	kWH/Yr	$/Year	LCC $	$/Year	LCC $	$	SIR	Payback	AIRR
Chilled Water Temperature Reset (506 C-1, 2105 C-1 & C-5) Recommended									
506 C-1	105,485	$8,755	$98,934	($528)	($5,671)	$10,101	9.23	1.23	21.19%
2105 C-1	20,550	$1,706	$19,273	($528)	($5,671)	$10,101	1.35	8.58	6.59%
2105 C-5	20,550	$1,706	$19,273	($528)	($5,671)	$10,101	1.35	8.58	6.59%
Total Chilled Water Temperature Resets	**146,585**	**$12,167**	**$137,480**	**($1,584)**	**($17,013)**	**$30,303**	**3.98**	**2.86**	**14.57%**
Chilled Water Temperature Reset (451, 2105 C-2, 3490) Not Recommend									
451	3,238	$269	$3,036	($528)	($5,671)	$10,101	(0.26)	(38.96)	-195.55%
506 C-2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2105 C-2	245	$20	$229	($528)	($5,671)	$10,101	(0.54)	(19.90)	-200.28%
3482	NA	NA	NA	NA	NA	NA	NA	NA	NA
3490 C-1	3,862	$321	$3,622	($528)	($5,671)	$10,101	(0.20)	(48.69)	-193.96%
3490 C-2	865	$72	$811	($528)	($5,671)	$10,101	(0.48)	(22.14)	-199.53%
3490 C-3	15	$1	$14	($528)	($5,671)	$10,101	(0.56)	(19.18)	-200.54%
3510	NA	NA	NA	NA	NA	NA	NA	NA	NA
Replace Glycol Chiller 506 C-2	**80,000**	**$6,640**	**$75,032**	**$0**	**$0**	**$62,606**	**1.20**	**9.43**	**5.77%**
Evaporative Precooling (Bldg 451 Test Case)	1,854	$154	$1,739	$0	$0	$11,964	0.15	77.75	-8.11%
Duty Cycling Controls kW Saved, one occurrence per year									
451	10.7	$338	$3,820	($66)	($709)	$2,554	1.22	9.39	5.88%
3490	26.1	$826	$9,337	($66)	($709)	$3,970	2.17	5.22	10.05%
Total Duty Cycling Controls	**36.8**	**$1,164**	**$13,157**	**($132)**	**($1,418)**	**$6,524**	**1.80**	**6.32**	**8.67%**
Electronic Expansion Valves (3482 & 3510)	**Project not evaluated due to high initial cost with limited return for single buildings.**								
Optimize Cooling Tower Control (Condensate Water Temperature Reset)	**Project not evaluated because all chiller systems are too small.**								
Manifold Chillers C-1, C-2 & C-3 at Building 3490	**92,825**	**$7,704**	**$87,060**	**($1,320)**	**($14,177)**	**$57,321**	**1.27**	**8.98**	**6.19%**

Note: Chiller refrigerant replacement, refrigerant containment and chiller replacement projects are not included in the above summary as they are not energy conservation projects. Refer to Section: Refrigerant Plan, Table 2 for a summary of these recommended actions.

Conversion to Non-Chlorofluorocarbon Refrigerants

Conversion to Non-Chlorofluorocarbon Refrigerants is addressed in Section 5.0. This appendix contains cost estimates and analyses of the various alternatives available for each of the study chillers. Chlorofluorocarbon containing refrigerants are due for phase-out of production based on a schedule required by the Montreal Protocol. The phase-out schedule for applicable refrigerants is as follows:

- CFC refrigerants (CFC-11 and CFC-113) are due for complete phase-out of production by January 1996.
- HCFC refrigerants (HCFC-22) are due for complete production phase-out by the year 2030, but are effectively phased out by 2020 with a 0.5% production cap.

Refrigerants used by each of the study chillers are shown on Table 5-3 (Volume I); a summary of information shown on this table is repeated on Table 1 below for convenience.

Table 1: Summary of Study Chillers and Refrigerants

Building Number	Unit Description	Refrigerant
451	55 Ton A/C Reciprocating Chiller	HCFC-22
506	220 Ton W/C Centrifugal Chiller	CFC-11
506	45 Ton A/C Reciprocating Glycol Chiller	HCFC-22
2105 C1	125 Ton W/C Centrifugal Chiller	CFC-113
2105 C2	40 Ton W/C Reciprocating Chiller	HCFC-22
2105 C5	125 Ton W/C Centrifugal Chiller	CFC-11
3482	62 Ton W/C Reciprocating DX Unit	HCFC-22
3490 C1	25 Ton A/C Reciprocating Chiller	HCFC-22
3490 C2	50 Ton A/C Reciprocating Chiller	HCFC-22
3490 C3	100 Ton A/C Reciprocating Chiller	HCFC-22
3510	40 Ton W/C Reciprocating DX Unit	HFC-134a
A/C = Air Cooled W/C = Water Cooled		

Options available for compliance with the Montreal Protocol include the following:

- Continue using and **contain** existing refrigerants until unit is to be replaced.
- Retrofit unit for **conversion** of refrigerant to a non-CFC refrigerant.
- **Replace** unit with one built for an HFC refrigerant (not regulated by the Montreal Protocol).

Each of these options requires installation of equipment. Cost estimates are attached for pertinent retrofits. A summary of retrofit costs appears as Table 2.

HCFC-22 and HCFC-113 Refrigerant Devices

There currently are no replacement refrigerants for HCFC's (HCFC-22 and 113) and the phase out period is many years away; thus, it is recommended that HCFC devices remain in service until due for replacement. The cost of installing refrigerant recovery and recycle units, including reseatable relief valves is about $12,500 (vendor quote), requiring an investment of about $14,000 (adding 6% each for SIOH and Design).

Several chillers and DX units are near the ends of their economic life-times and are recommended for replacement at, or before, failure.

Conversion to Non-Chlorofluorocarbon Refrigerants

Refrigerant replacement analysis was conducted by contacting various chiller and refrigerant manufacturers. (Records of Telephone Conversations are attached.) Cost estimates for refrigerant replacement and necessary chiller alteration costs are also attached. The chiller alterations are necessary to retain as much of the unit capacity as possible and to contain the new refrigerant.

Chiller Replacement

Replacing existing chillers and DX cooling units with new units using less environmentally-hazardous refrigerants is considered. Unit replacements are recommended for several units. (See Table 2.) These recommendations are made when costs to either install containment equipment or replace refrigerants would be wasted on equipment near the end of their economic lives.

Building 506 - 45 Ton Air Cooled R-22 Glycol Chiller Replacement (Ice-On-Coil System)

The Glycol Chiller used for the Ice-On-Coil System is presently rated at a capacity of 45 Tons. The unit was recently converted from a standard chiller rated at 80 Tons capacity; it has been derated for colder-temperature application. Replacement of this converted chiller with one designed for cold temperature application is evaluated.

Based on manufacturer's data, the Ice-On-Coil glycol chiller provides 49.7 tons of refrigeration at 105 °F outside air temperature while drawing 103.9 kW of electric power. Newer chillers designed initially for low temperature operation can provide the same degree of cooling while drawing only 90.2 kW.

Based on daily use of 16 hours per day (20 hours per day are scheduled), year-round, savings are:

(103.9 - 90.2) kW x 16 Hours/Day x 365 Days/Year = 80,000 kWh/Year

The incremental cost of electric power is $0.083 per kWH, thus, annual power cost savings are:

(80,000 kWH/Year x $0.083 = $6,640 per year saved

Life cycle energy cost savings are:

11.30 (UPW for electric power, N=15 Years) x $6,640 = $ 75,032

Maintenance costs would be about the same as they are for the existing chiller.

The required investment is about (see attached cost estimate):

$55,898 x 1.12 (SIOH & Design) = $ 62,606

The payback period is, thus:

Investment ÷ Annual Energy Cost Savings = 9.43 Years

And the Savings to Investment Ratio (SIR) is:

$ 75,032 (Life Cycle Cost Savings) ÷ (Investment) $ 62,606 = 1.20

Table 2: Cost Summary for Recommended Non-Chlorofluorocarbon Refrigerant Compliance (1)

Building Number	Unit Description (2)	Contain Refrigerant	Replace Refrigerant	Replace Unit	Recommended Investment (3)	Explanation
451	55 Ton A/C Reciprocating Chiller	**$ 12,500**	-	$ 60,574	$ 14,000	
506 C1	220 Ton W/C Centrifugal Chiller	$ 12,500	$ 17,680	**$ 159,424**	$ 178,555	Unit is now 20 years old & due for replacement
506 C2	45 Ton A/C Reciprocating Glycol Chiller	$ 12,500	-	**$ 55,898**	$ 62,606	Analysis shows this option is the most cost effective.
2105 C1	125 Ton W/C Centrifugal Chiller	$ 12,500	$ 16,728	**$ 145,558**	$ 163,025	Unit is now 17 years old & due for replacement
2105 C2	40 Ton W/C Reciprocating Chiller	$ 12,500	-	**$ 46,792**	$ 52,408	Unit is now 17 years old & due for replacement
2105 C5	125 Ton W/C Centrifugal Chiller	**$ 12,500**	$ 16,728	$ 145,558	$ 14,000	Unit is only 10 years old at this time, contain refrigerant until unit is replaced.
3482	62 Ton W/C Reciprocating DX Unit	$ 12,500	-	**$ 53,992**	$ 60,471	Unit is now 24 years old & due for replacement
3490 C1	25 Ton A/C Reciprocating Chiller	**$ 12,500**	-	$ 32,138	$ 14,000	Unit is only 7 years old at this time, contain refrigerant until replacement unit needed.
3490 C2	50 Ton A/C Reciprocating Chiller	**$ 12,500**	-	$ 57,312	$ 14,000	Unit is only 7 years old at this time, contain refrigerant until replacement unit needed.
3490 C3	100 Ton A/C Reciprocating Chiller	**$ 12,500**	-	$ 112,800	$ 14,000	Unit is only 7 years old at this time, contain refrigerant until replacement unit needed.
3510	40 Ton W/C Reciprocating DX Unit	**$ 12,500**	-	$ 38,932	$ 14,000	Unit was converted to HCFC-134a in 1993, retrofit refrigerant containment equipment.
Total Probable Construction Cost					**$ 601,064**	Recommended for chiller retrofits at current time.

Notes:
1. Recommended options are displayed in **Bold-Face** type.
2. Condenser types: A/C = Air Cooled; W/C = Water Cooled
3. Investment includes construction costs plus 6% for SIOH and 6% for design.

CONSTRUCTION COST ESTIMATE

Date Prepared: January 1994	Sheet 1	Of 1

Project	EEAP Limited Energy Study
Project No.	
Location	Yuma Proving Ground, Arizona
Engineer-Architect	Keller & Gannon
Basis for Estimate	Code A (no design competed)
Drawing No.	**Contain Refrigerant**
Estimator	R. Bush
Checked By	B. Horst

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Install Refrigerant Recovery & Recycle Unit and Reseatable Relief Valve; Replace Purge Unit	1	EA	Vendor Quote to Perform Work, including "Below-the-Line" Costs				$12,500
Subtotal							$12,500
State Sales Tax	Included above						$0
Subtotal							$12,500
Contractor OH & Profit	Included above						$0
Subtotal							$12,500
Bond	Included above						$0
Subtotal							$12,500
Estimating Contingency	Included above						$0
Total Probable Construction Cost							**$12,500**

CONSTRUCTION COST ESTIMATE					Date Prepared January 1994		Sheet 1 Of 1	
Project EEAP Limited Energy Study				Project No.	Basis for Estimate **Code A (no design competed)**			
Location Yuma Proving Ground, Arizona								
Engineer-Architect Keller & Gannon								
Drawing No. **Replace Chiller - Bldg 451**		Estimator R. Bush			Checked By B. Horst			

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Remove Existing Chiller	1	EA	$7,575	$7,575	$ -	$0	$7,575
Chiller, 55 Ton Air Cooled, Reciprocating	1	EA	$ 10,100	$10,100	$ 23,000	$23,000	$33,100
Subtotal				$17,675		$23,000	$40,675
State Sales Tax	5.5%	%		-		$1,265	$1,265
Subtotal							$41,940
Contractor OH & Profit	30.0%	%					$12,582
Subtotal							$54,522
Bond	1.0%	%					$545
Subtotal							$55,067
Estimating Contingency	10.0%	%					$5,507
Total Probable Construction Cost							**$60,574**

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1 Of 1

Project EEAP Limited Energy Study	Project No.	Basis for Estimate **Code A (no design competed)**
Location Yuma Proving Ground, Arizona		
Engineer-Architect Keller & Gannon		

Drawing No. **Replace Chiller No.1 - Bldg 506**	Estimator R. Bush	Checked By B. Horst

Line Item	Quantity No. Units	Quantity Unit Meas.	Labor Per Unit	Labor Total	Material Per Unit	Material Total	Total Cost
Remove Existing Chiller	1	EA	$16,425	$16,425	$ -	$0	$16,425
220 Ton Centrifugal	1	EA	$21,900	$21,900	$68,300	$68,300	$90,200
Subtotal				$38,325		$68,300	$106,625
State Sales Tax	5.5%	%		-		$3,757	$3,757
Subtotal							$110,382
Contractor OH & Profit	30.0%	%					$33,114
Subtotal							$143,496
Bond	1.0%	%					$1,435
Subtotal							$144,931
Estimating Contingency	10.0%	%					$14,493
Total Probable Construction Cost							$159,424

CONSTRUCTION COST ESTIMATE					Date Prepared January 1994		Sheet 1 Of 1	
Project EEAP Limited Energy Study					Project No.	Basis for Estimate		
Location Yuma Proving Ground, Arizona						Code A (no design competed)		
Engineer-Architect Keller & Gannon								
Drawing No. Replace Refrigerant - Bldg 506, C1		Estimator R. Bush				Checked By B. Horst		

Line Item	Quantity No. Units	Quantity Unit Meas.	Labor Per Unit	Labor Total	Material Per Unit	Material Total	Total Cost
Refrigerant replacement for CFC-11	450	Lb.	$0.36	$162	$6.60	$2,970	$3,132
Oil Change	1	EA	$80	$80	$200	$200	$280
Subtotal				$242		$3,170	$3,412
State Sales Tax	5.5%	%		-		$174	$174
Subtotal							$3,586
Contractor OH & Profit	30.0%	%					$1,076
Subtotal							$4,662
Bond	1.0%	%					$47
Subtotal							$4,709
Estimating Contingency	10.0%	%					$471
Subtotal Probable Construction Cost							$5,180
Install Refrigerant Recovery & Recycle Unit and Reseatable Relief Valve; Replace Purge Unit	1	EA	Vendor Quote to Perform Work, including "Below-the-Line" Costs				$12,500
Total Probable Construction Cost							$ 17,680

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1 Of 1
Project EEAP Limited Energy Study	Project No.	Basis for Estimate Code A (no design competed)
Location Yuma Proving Ground, Arizona		
Engineer-Architect Keller & Gannon		
Drawing No. Replace Glycol Chiller - Bldg 506	Estimator BIH	Checked By RCL

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Building 506 Glycol Chiller							
Air Cooled Glycol Chiller	1	EA	$4,710	$4,710	$26,640	$26,640	$31,350
Remove Existing Chiller	1	EA	$5,888	$5,888	$0	$0	$5,888
Subtotal				$10,598		$26,640	$37,238
State Sales Tax	5.5%	%		-		$1,465	$1,465
Subtotal							$38,703
Contractor OH & Profit	30.0%	%					$11,611
Subtotal							$50,314
Bond	1.0%	%					$503
Subtotal							$50,817
Estimating Contingency	10.0%	%					$5,082
Total Probable Construction Cost							**$55,898**

CONSTRUCTION COST ESTIMATE

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1 Of 1
Project EEAP Limited Energy Study	Project No.	Basis for Estimate **Code A (no design competed)**
Location Yuma Proving Ground, Arizona Bldg 2105 - 125 Ton Chiller		
Engineer-Architect Keller & Gannon		
Drawing No. **Replace 125 Ton Chiller - Bldg 2105**	Estimator R. Bush	Checked By B. Horst

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Remove Existing Chiller	1	EA	$16,425	$16,425	$ -	$0	$16,425
125 Ton Centrifugal	1	EA	$21,900	$21,900	$68,300	$59,200	$81,100
Subtotal				$38,325		$59,200	$97,525
State Sales Tax	5.5%	%		-		$3,256	$3,256
Subtotal							$100,781
Contractor OH & Profit	30.0%	%					$30,234
Subtotal							$131,015
Bond	1.0%	%					$1,310
Subtotal							$132,325
Estimating Contingency	10.0%	%					$13,233
Total Probable Construction Cost							**$145,558**

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1 Of 1
Project EEAP Limited Energy Study	Project No.	Basis for Estimate Code A (no design competed)
Location Yuma Proving Ground, Arizona Bldg 2105 - 125 Ton Chiller		
Engineer-Architect Keller & Gannon		
Drawing No. **Building 2105 Chiller: Replace Refrigerant - 125 Ton**	Estimator R. Bush	Checked By B. Horst

Line Item	Quantity No. Units	Quantity Unit Meas.	Labor Per Unit	Labor Total	Material Per Unit	Material Total	Total Cost
Refrigerant	360	Lb.	$0.36	$130	$6.60	$2,376	$2,506
Oil Change	1	EA	$80	$80	$200	$200	$280
Subtotal				$210		$2,576	$2,786
State Sales Tax	5.5%	%		-		$142	$142
Subtotal							$2,927
Contractor OH & Profit	30.0%	%					$878
Subtotal							$3,805
Bond	1.0%	%					$38
Subtotal							$3,844
Estimating Contingency	10.0%	%					$384
Subtotal Probable Construction Cost							$4,228
Install Refrigerant Recovery & Recycle Unit and Reseatable Relief Valve; Replace Purge Unit	1	EA	Vendor Quote to Perform Work, including "Below-the-Line" Costs				$12,500
Total Probable Construction Cost							**$ 16,728**

CONSTRUCTION COST ESTIMATE

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1	Of 1
Project EEAP Limited Energy Study	Project No.	Basis for Estimate Code A (no design competed)	
Location Yuma Proving Ground, Arizona			
Engineer-Architect Keller & Gannon			
Drawing No. **Building 2105 Chiller 2: Replace Chiller - 40 Tons**	Estimator R. Bush	Checked By B. Horst	

Line Item	Quantity No. Units	Quantity Unit Meas.	Labor Per Unit	Labor Total	Material Per Unit	Material Total	Total Cost
40 Ton Water Cooled, Reciprocating Chiller, Hermetic	1	EA	$7,300	$7,300	$18,600	$18,600	$25,900
Remove Existing Chiller	1	EA	$ 5,475	$5,475	$ -	$0	$5,475
Subtotal				$12,775		$18,600	$31,375
State Sales Tax	5.5%	%		-		$1,023	$1,023
Subtotal							$32,398
Contractor OH & Profit	30.0%	%					$9,719
Subtotal							$42,117
Bond	1.0%	%					$421
Subtotal							$42,539
Estimating Contingency	10.0%	%					$4,254
Total Probable Construction Cost							**$46,792**

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1 Of 1
Project EEAP Limited Energy Study	Project No.	Basis for Estimate **Code A (no design competed)**
Location Yuma Proving Ground, Arizona		
Engineer-Architect Keller & Gannon		
Drawing No. **Replace DX Unit - Bldg 3482**	Estimator R. Bush	Checked By B. Horst

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
62 Ton Water Cooled DX Cooling Unit, nic Condenser	1	EA	$8,390	$8,390	$21,517	$21,517	$29,907
Remove Existing Chiller	1	EA	$ 6,293	$6,293	$ -	$0	$6,293
Subtotal				$14,683		$21,517	$36,199
State Sales Tax	5.5%	%		-		$1,183	$1,183
Subtotal							$37,383
Contractor OH & Profit	30.0%	%					$11,215
Subtotal							$48,597
Bond	1.0%	%					$486
Subtotal							$49,083
Estimating Contingency	10.0%	%					$4,908
Total Probable Construction Cost							$53,992

CONSTRUCTION COST ESTIMATE	Date Prepared: January 1994	Sheet 1 Of 1
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: Code A (no design competed)
Location: Yuma Proving Ground, Arizona		
Engineer-Architect: Keller & Gannon		
Drawing No.: Replace Chillers - Bldg 3490	Estimator: R. Bush	Checked By: B. Horst

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Chiller 1							
25 Ton Air Cooled Chiller	1	EA	$5,300	$5,300	$12,300	$12,300	$17,600
Remove Existing Chiller	1	EA	$ 3,975	$3,975	$ -	$0	$3,975
Subtotal				$9,275		$12,300	$21,575
State Sales Tax	5.5%	%		-		$677	$677
Subtotal							$22,252
Contractor OH & Profit	30.0%	%					$6,675
Subtotal							$28,927
Bond	1.0%	%					$289
Subtotal							$29,216
Estimating Contingency	10.0%	%					$2,922
Total Probable Construction Cost							**$32,138**
Chiller 2							
50 Ton Air Cooled Chiller	1	EA	$8,900	$8,900	$22,850	$22,850	$31,750
Remove Existing Chiller	1	EA	$ 6,675	$6,675	$ -	$0	$6,675
Subtotal				$15,575		$22,850	$38,425
State Sales Tax	5.5%	%		-		$1,257	$1,257
Subtotal							$39,682
Contractor OH & Profit	30.0%	%					$11,905
Subtotal							$51,586
Bond	1.0%	%					$516
Subtotal							$52,102
Estimating Contingency	10.0%	%					$5,210
Total Probable Construction Cost							**$57,312**
Chiller 3							
100 Ton Air Cooled Chiller	1	EA	$17,500	$17,500	$45,000	$45,000	$62,500
Remove Existing Chiller	1	EA	$ 13,125	$13,125	$ -	$0	$13,125
Subtotal				$30,625		$45,000	$75,625
State Sales Tax	5.5%	%		-		$2,475	$2,475
Subtotal							$78,100
Contractor OH & Profit	30.0%	%					$23,430
Subtotal							$101,530
Bond	1.0%	%					$1,015
Subtotal							$102,545
Estimating Contingency	10.0%	%					$10,255
Total Probable Construction Cost							**$112,800**

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1 Of 1

Project EEAP Limited Energy Study	Project No.	Basis for Estimate **Code A (no design competed)**
Location Yuma Proving Ground, Arizona		
Engineer-Architect Keller & Gannon		
Drawing No. **Replace DX Unit - Bldg 3510**	Estimator R. Bush	Checked By B. Horst

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
40 Ton Water Cooled DX Cooling Unit, nic Condenser	1	EA	$6,300	$6,300	$15,100	$15,100	$21,400
Remove Existing Chiller	1	EA	$ 4,725	$4,725	$ -	$0	$4,725
Subtotal				$11,025		$15,100	$26,125
State Sales Tax	5.5%	%		-		$831	$831
Subtotal							$26,956
Contractor OH & Profit	30.0%	%					$8,087
Subtotal							$35,042
Bond	1.0%	%					$350
Subtotal							$35,393
Estimating Contingency	10.0%	%					$3,539
Total Probable Construction Cost							**$38,932**

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Building 506

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Chiller Study Fiscal Year FY96
Discrete Portion: Replace Glycol Chiller for Ice-On-Coil System Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$55,898		
B. SIOH	$ 3,354		
C. Design Cost	$ 3,354		
D. Total Cost (1A+1B+1C)	$ 62,606		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$62,606

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/kWH	Saving kWH/Year (2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	80,000	$6,640	11.30	$75,032
B. Dist			$0		
C. LPG			$0		
D. Other			$0		
E. Demand Savings			$0		
F. Total		80,000	$6,640		$75,032

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	$0		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			$0

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) $0

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)): 9.43 Years
5. Total Net Discounted Savings (2F5+3C): $75,032
6. Savings to Investment Ratio (SIR) 5/1G: 1.20
7. Adjusted Internal Rate of Return (AIRR): 5.77%

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10 January 1994

RECORD OF TELEPHONE CONVERSATION

BETWEEN:	Richard Frenzel
AND:	Ron Bush
DATE & TIME:	1/10/94 11:00 A.M.
SUBJECT:	Carrier Air Cooled Recip. Chiller
K&G PROJECT NO.:	16-403-11

1. I called Richard to inquire as to the viability of converting a 55 Ton Carrier Model 30GB-55 from R-22 to HFC-134a. The new refrigerant has different operating temperatures and pressures then R-22. Simply replacing the refrigerant would reduce the efficiency of the chiller by more then one half. In order to convert the chiller for efficient use of HFC-134a the majority of the components would have to be replaced or retrofitted. The cost of this would amount to that of a brand new chiller and the efficiency would still not equal that of the R-22 charged machine. In order to account for the phasing out of R-22 beginning in 1996, the Carrier Corporation is introducing a new line of air cooled reciprocating chillers which will come factory charged with HFC-134a. The cost of the new chillers has not been established as the machines will not enter the market until the end of this year. The conclusion is that any existing air cooled reciprocating chiller charged with R-22 should remain for the extent of its useful life. At this time the chiller should be replaced with one designed to operate with HFC-134a.

\1640311\ENGR\CARRIER.TEL
940110-1

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Phone: (415) 621-1199 FAX: (415) 864-3681
Mail: P.O. Box 422430, San Francisco, CA 94142-2430

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10 January 1994

RECORD OF TELEPHONE CONVERSATION

BETWEEN:	Jeff Kerl of Carrier Co.
AND:	Ron Bush
DATE & TIME:	1/10/94 2:00 P.M.
SUBJECT:	Carrier Chiller
K&G PROJECT NO.:	16-403-11

1. I called Jeff to inquire as to the viability of converting a 125 ton Carrier chiller from R-11 refrigerant to HCFC-123. He said that due to the toxicity of the refrigerant, Carrier instructs their field workers not to do the conversions. In addition, due to the operating characteristics of the new refrigerant, several alterations must be made to the chiller. The conversion would reduce the output of the chiller by ten to twenty percent. In order to retain the same output after the conversion the following alterations would have to be made.

A.	New gasketing for the entire chiller.	$20,000
B.	New compressor.	$25,000
C.	New motor.	$25,000
D.	Containment*	$30,000
Total		$100,000

Since this approximately totals the cost of a new chiller it is recommended that the R-11 not be converted to R-123.

* Containment includes a high efficiency purge process as well as a heater blanket placed under a vacuum. The purpose of the heater blanket is to heat the refrigerant to slightly above atmospheric pressure to keep non-condensables out of the machine during the refrigerant replacement.

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13 January 1994

RECORD OF TELEPHONE CONVERSATION

BETWEEN:	Allison Johnson of Dupont 1-800-582-5606
AND:	Ron Bush of Keller & Gannon
DATE & TIME:	1/13/94
SUBJECT:	CFC Replacements
K&G PROJECT NO.:	1640311

1. I called Allison to discuss replacement refrigerants for R-11, R-12 and R-22. I informed her that all the chiller manufacturers I have spoken with have recommended that equipment running on these refrigerants should be replaced with brand new equipment designed to operate on one of the new HCFC refrigerants being phased in. Allison said Dupont does nothing for R-22 replacement at this time but does recommend replacing R-11 and R-12 refrigerants. Dupont sells several replacements for R-12. For Centrifugal chillers they sell R-134a at $7.24/lb. For everything else they sell either MP-39 or MP-66 at $6.60/lb. They only replacement necessary on the equipment is the oil. Efficiencies are a little lower with the replacement refrigerants.

\1640311\DUPONT.MEM
940113-1

1453 Mission Street, San Francisco, California 94103
Phone: (415) 621-1199 FAX: (415) 864-3681
Mail: P.O. Box 422430, San Francisco, CA 94142-2430

Chilled Water Temperature Reset

Introduction:

Raising the chilled water temperature, or evaporator temperature, will reduce compressor load, and thus, energy consumption. The chiller Coefficient of Performance (COP) is improved, for example, reciprocating chiller efficiency is increased by up to 5.8% for a 5 Degree increase in chilled water supply temperature.

Chiller & Refrigeration Systems Evaluated:

Chiller systems evaluated include the following:

Bldg No.	Air Cooled	Water Cooled	Refrig. Tons	Remarks
451	X		55	Reciprocating
506		X	220	Centrifugal
506	X		45	Recip. Glycol Ice-On-Coil System: Cannot raise Temp
2105 C1		X	125	Centrifugal
2105 C2		X	40	Reciprocating
2105 C5		X	125	Centrifugal
3490 C1	X		25	1 Reciprocating Compressor
3490 C2	X		50	2 Reciprocating Compressor
3490 C3	X		100	4 Reciprocating Compressor

Energy Saving Calculations:

Existing chiller performance is based on field measurements of load and power demand of partially loaded chillers and on catalog performance data.

The energy savings for chilled water reset were calculated by taking all the instances in which the outdoor ambient temperature was below 75°F and, if there was a chiller demand, raising the leaving chilled water temperature from one to five degrees. The assumption was made that in instances when the outdoor temperature was below 75°F, the chilled water temperature could be raised and still satisfy the cooling load at the same flow rate. Calculations used for developing the accompanying spread sheet and graphical analyses (See Figures 1 through 8) for each chiller follow:

Note: The Ice-On-Coil glycol chiller system CHWS temperature may not be raised; this chiller is excluded.

Abbreviations:

BTU	British Thermal Unit
BTUH	British Thermal Units per Hour
KW	Kilowatts (Field measurement of chiller load)
KWH	Kilowatt hours
EER	Energy Efficiency Ratio (BTUH out ÷ Watts in)
T_r	Chilled Water Temperature Rise (For Saving Calculations) (°F)
T_{OA}	Outside Air Temperature Rise (Field measurement) (°F)
ΔT	Temperature Differential (Field measurement) (°F)
GPM	Gallons per minute (Field measurement)
Cooling Factor	Ratio of Annual Hours below 75°F to measurement period hours below 75°F ÷ 365.
EER	If(GPM x 500 x ΔT) > 0, Then: EER = BTU ÷ (KWH/1000)
BTUH (Load)	GPM x 500 x ΔT

Energy Saving Calculation:

The following are calculated for 5 minute measurement periods; results are averaged or totaled, as needed, to determine savings during that time and are then extended to annual savings using the Cooling Factor.

BTUH	If(T_{OA} < 75 °F) and If(Load) > 0, Then:
	Savings (BTUH) = Load - (500 x ($\Delta T - T_r$) x GPM)
KW	If(EER) > 0, Then: KW = (BTUH ÷ EER) ÷ 1,000
KWH/Day	KW x (5 Minute measurement ÷ 60 Minutes per Hour) x Cooling Factor
KWH/Year	KWH/Day x 365 Days/Year

Cooling Factor Calculation:

Bldg No.	Analysis Hr<75°F	Annual Hr<75°F	Cooling Factor
451	5.08	5,236	2.824
506	14.67	5,236	0.978
2105 C1	5.68	5,236	2.526
2105 C2	1.08	5,236	13.283
2105 C5	5.68	5,236	2.526
3490 C1	4.75	5,236	3.020
3490 C2	2.67	5,236	5.373
3490 C3	1.58	5,236	9.079

Annual hours below 75°F are from TM 5-785. Analysis hours below 75°F are based on field measurements.

Cost Saving Calculation:

Annual energy cost savings are based on KWH savings per year as calculated above times power cost:

Electric Energy Cost: $ 0.0830 per KWH, including demand charges. Results are tabulated on Table 1.

Operations and Maintenance Costs:

Control systems proposed in this project will require preventive maintenance and periodic calibration. It is assumed that this will require a total of about 16 hours per year of additional O&M effort for each system.

16 MH/Yr x $22/MH x 1.5 (Benefits & OH) $528 per Year added O&M Cost

Added LCC O&M Cost: 10.74 (UPW Factor) x $528/Yr = $ 5,671 Added LCC Costs

Modifications Required:

Raise chilled water temperature to "follow the load": Install a limit switch in each modulating or diversion valve to measure whether the valve is fully open or partially open. Arrange the control circuits so that when all coil control valves are either closed or in a partially open position (indicating light load conditions), the chilled-water temperature supply set point should be raised until one or more coil control valves return to the fully open position. Raise supply air temperature to follow the load. Installation costs are summarized on the attached cost estimate sheet.

Note: Tabular data from field measurements provided with the <u>Interim Submittal</u> has been deleted from this submittal.

Table 1: Chilled Water Reset ECO Calculations

Bldg No.	Savings: KWH/Day	Savings: KWH/Year	Savings: $/Year	Savings: LCC $	O&M Cost $/Year	O&M Cost LCC $	Investment $	Total Saved: $/Year	Total Saved: LCC $	Payback Period	SIR
Recommended Retrofits											
506 C1	289.00	105,485	$ 8,755	$ 98,934	$ 528	$ 5,671	$ 10,101	$ 8,227	$ 93,264	1.23	9.23
2105 C1	56.30	20,550	$ 1,706	$ 19,273	$ 528	$ 5,671	$ 10,101	$ 1,178	$ 13,603	8.58	1.35
2105 C5	56.30	20,550	$ 1,706	$ 19,273	$ 528	$ 5,671	$ 10,101	$ 1,178	$ 13,603	8.58	1.35
Totals for SIR > 1.0	**402**	**$ 146,584**	**$ 12,166**	**$ 137,481**	**$ 1,584**	**$ 17,012**	**$ 30,304**	**$ 10,582**	**$ 120,469**	**2.86**	**3.98**

Projects Not Recommended because SIR < 1.0											
451	8.87	3,238	$ 269	$ 3,036	$ 528	$ 5,671	$ 10,101	$ (259)	$ (2,634)	(38.96)	(0.26)
2105 C2	0.67	245	$ 20	$ 229	$ 528	$ 5,671	$ 10,101	$ (508)	$ (5,441)	(19.90)	(0.54)
3490 C1	10.58	3,862	$ 321	$ 3,622	$ 528	$ 5,671	$ 10,101	$ (207)	$ (2,049)	(48.69)	(0.20)
3490 C2	2.37	865	$ 72	$ 811	$ 528	$ 5,671	$ 10,101	$ (456)	$ (4,859)	(22.14)	(0.48)
3490 C3	0.04	15	$ 1	$ 14	$ 528	$ 5,671	$ 10,101	$ (527)	$ (5,657)	(19.18)	(0.56)

Figure 1: Building 451 Chiller
55 Ton Carrier 30GB-055-530AA

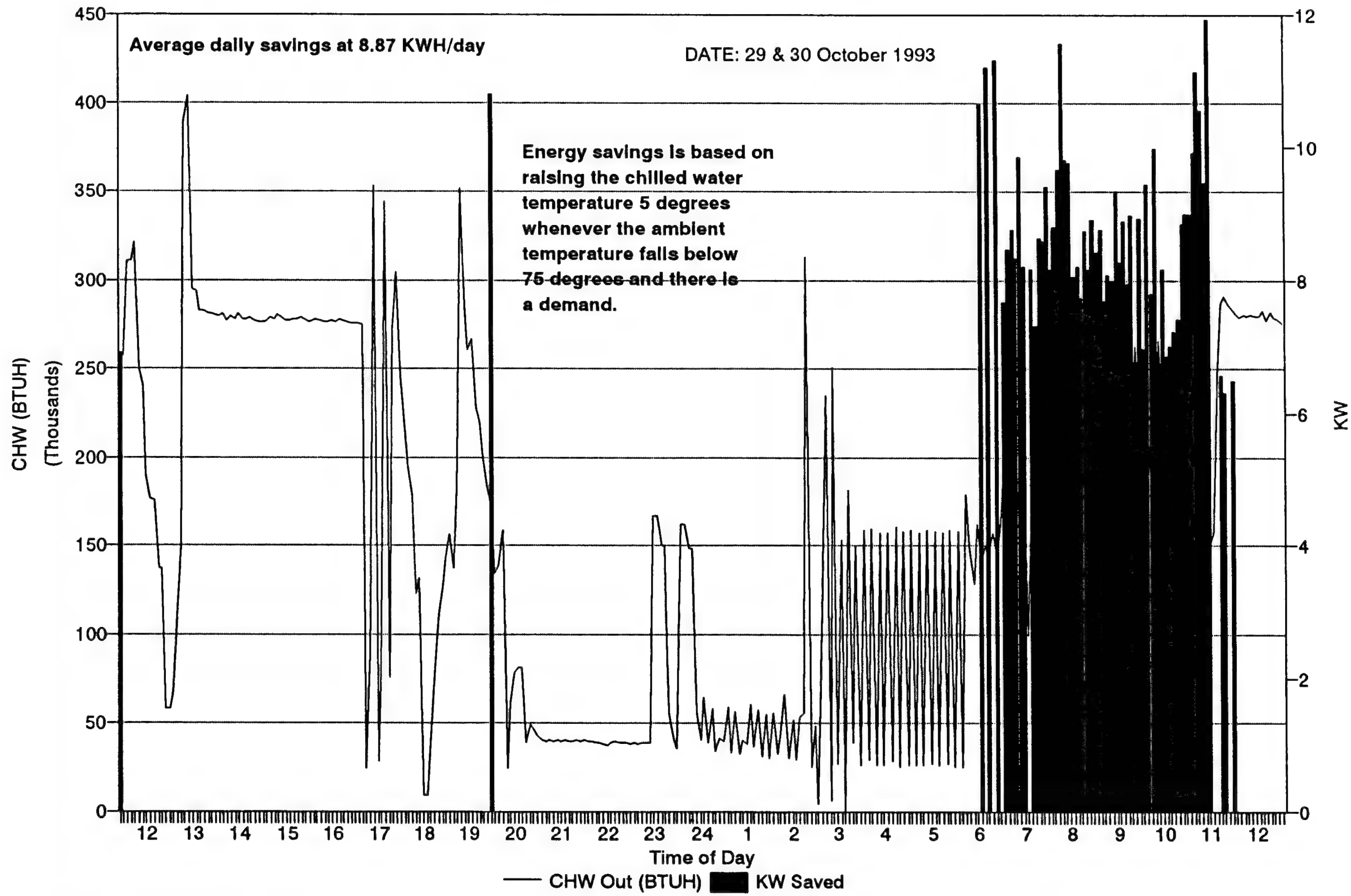


Figure 2: Building 506 Chiller
220 Ton Trane CVHE-020F-AL-2GB2451DEZA1

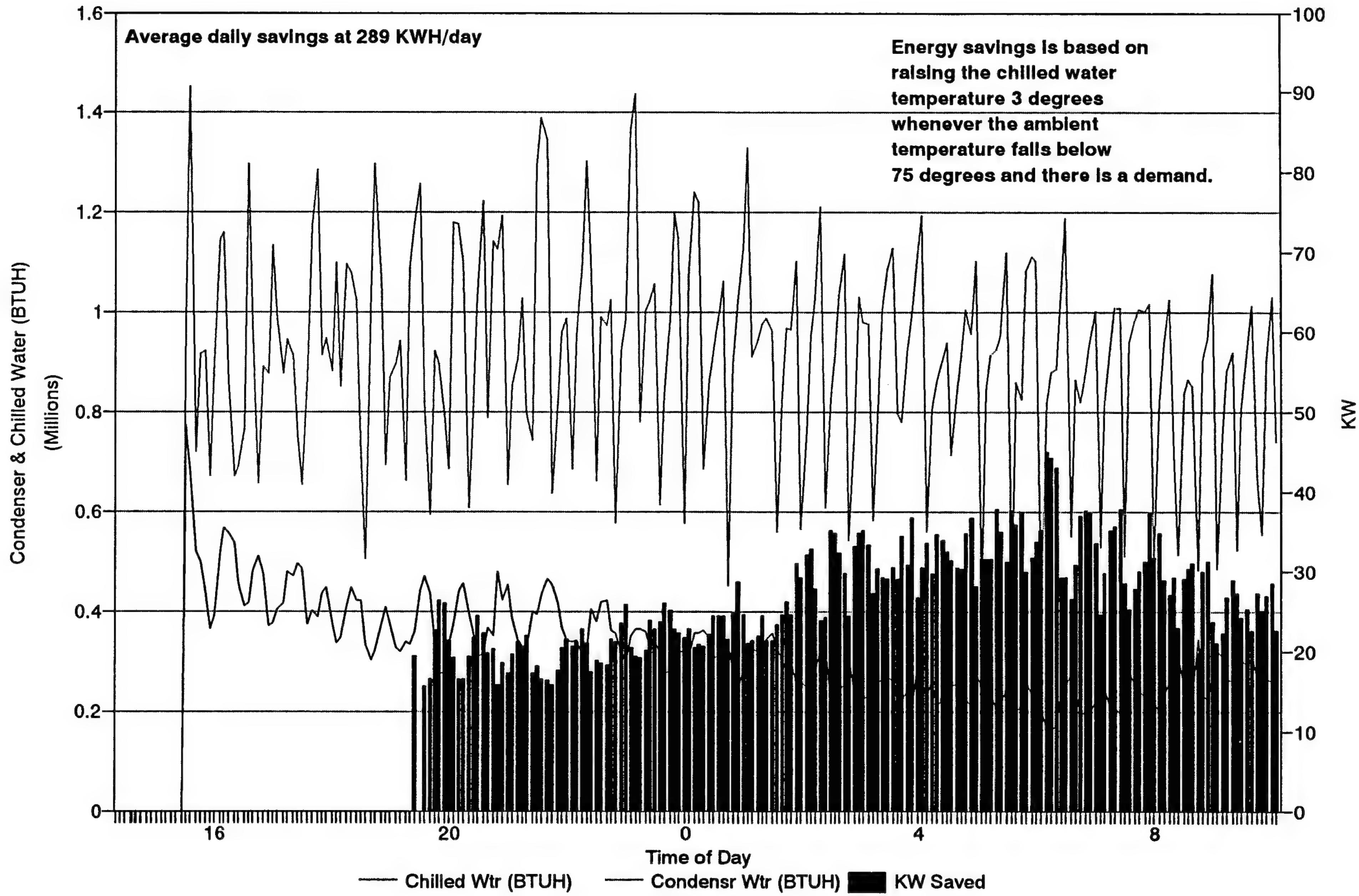


Figure 3: Building 2105 Chiller No. 1

125 Ton Carrier 19DK4629AE

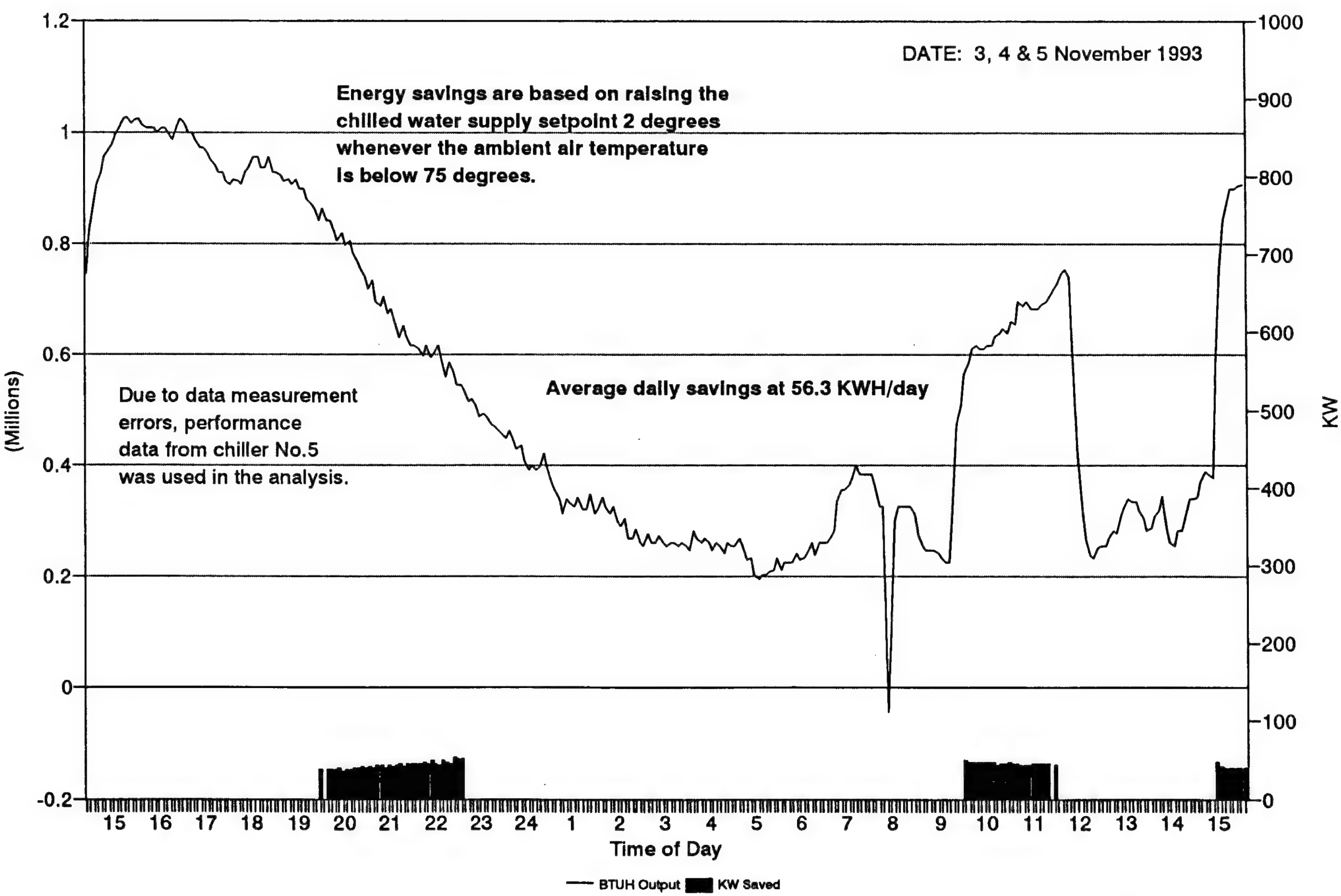
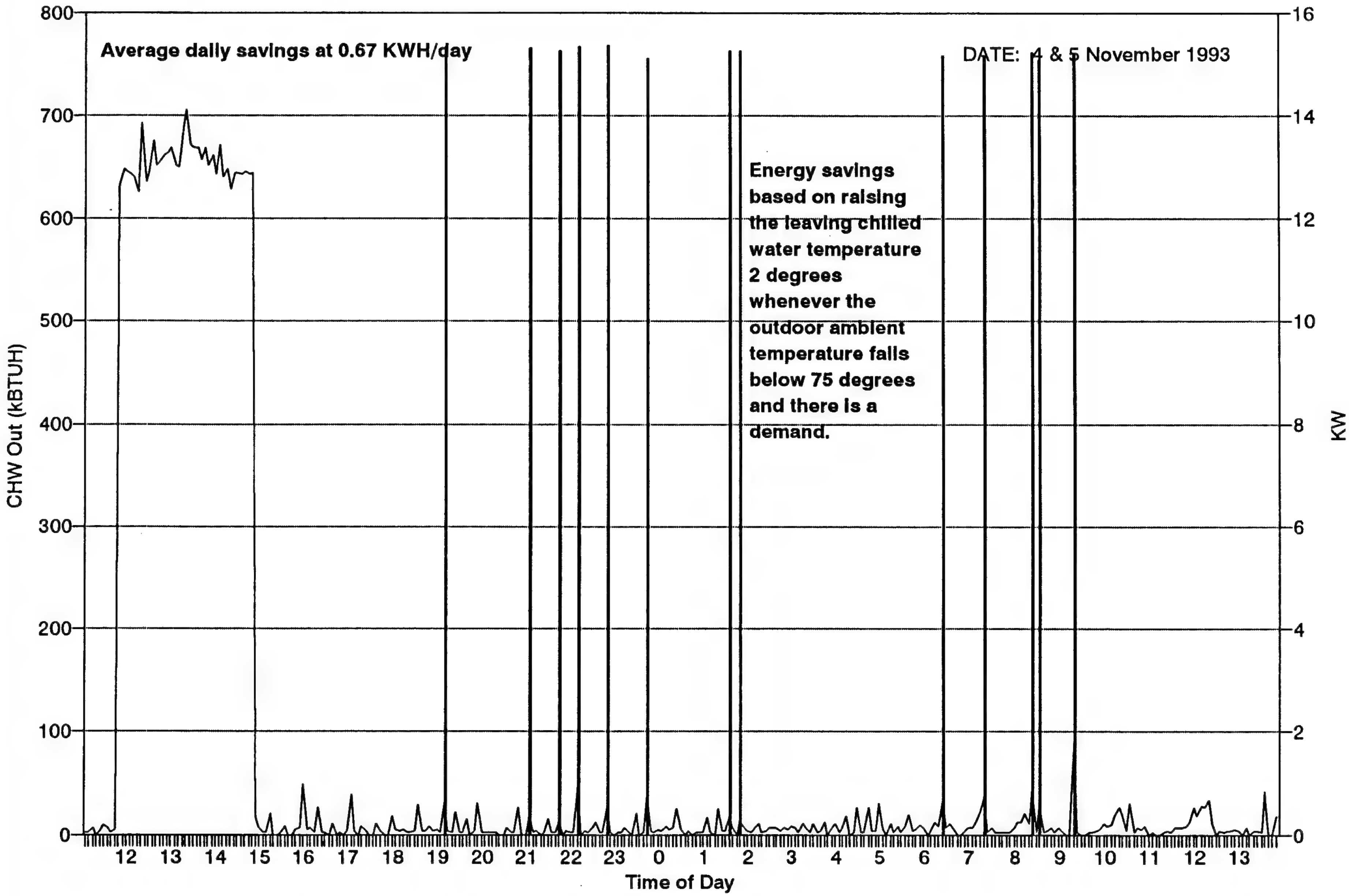


Figure 4: Building 2105 Chiller No. 2

40 Ton Trane CGWA0404RB51CC5C4B361BE



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APPENDIX F

Chilled Water Reset: Page 7

Figure 5: Building 2105 Chiller No. 5
125 Ton Carrier 19DK4629AE

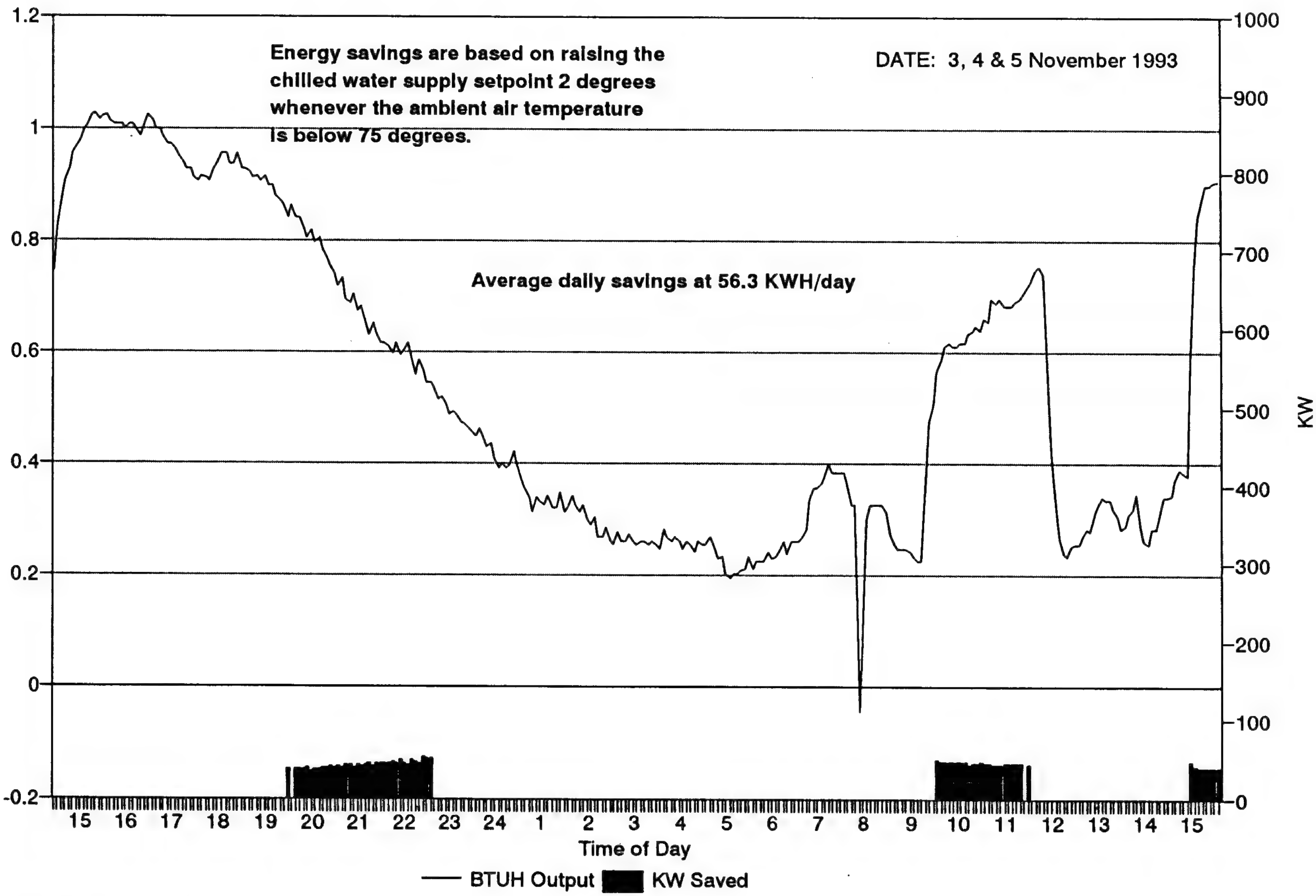


Figure 6: Building 3490 - Chiller C-1
25 Ton Air-Cooled Reciprocating Chiller

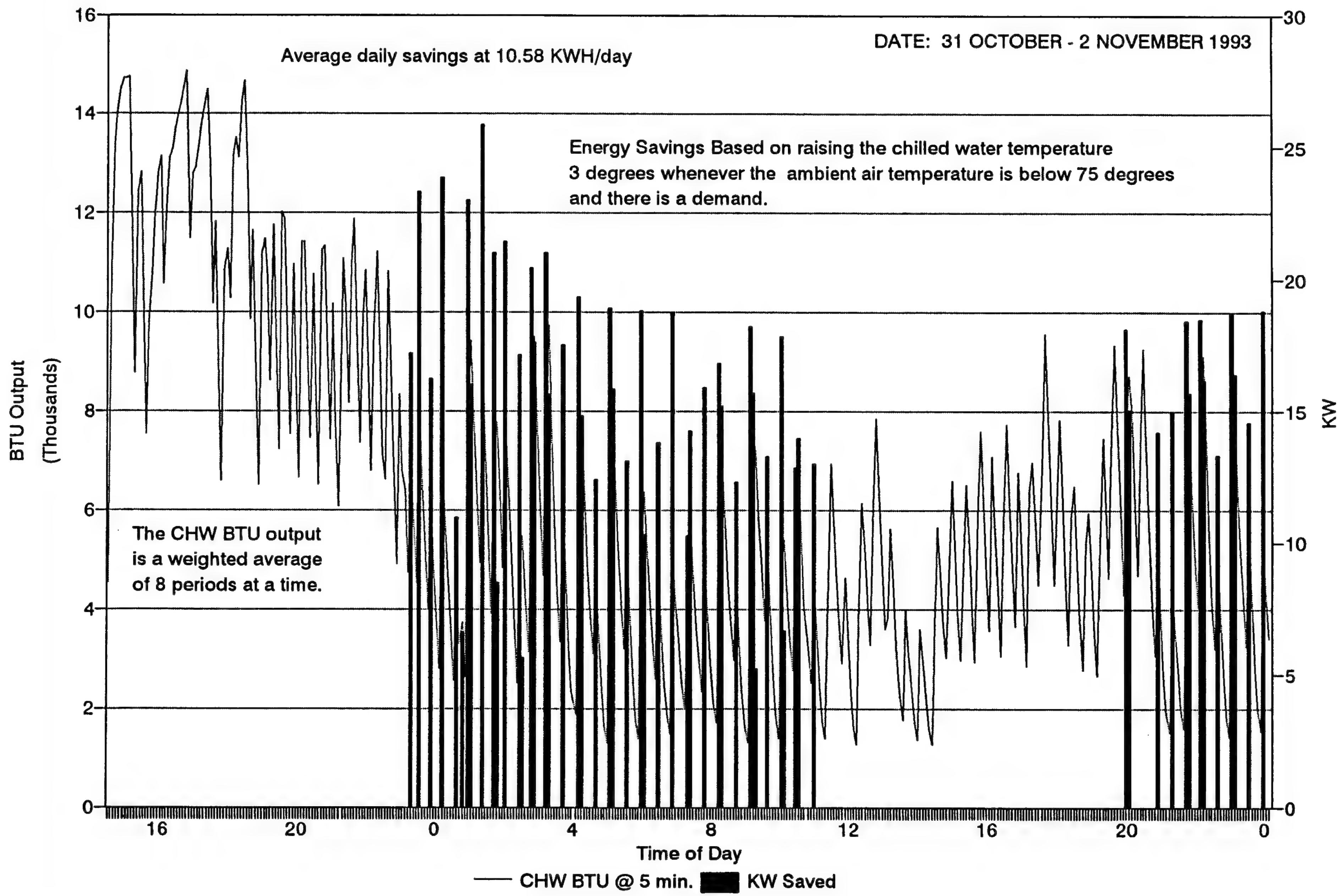


Figure 7: Building 3490 Chiller C-2

50 Ton Air Cooled Reciprocating Chiller

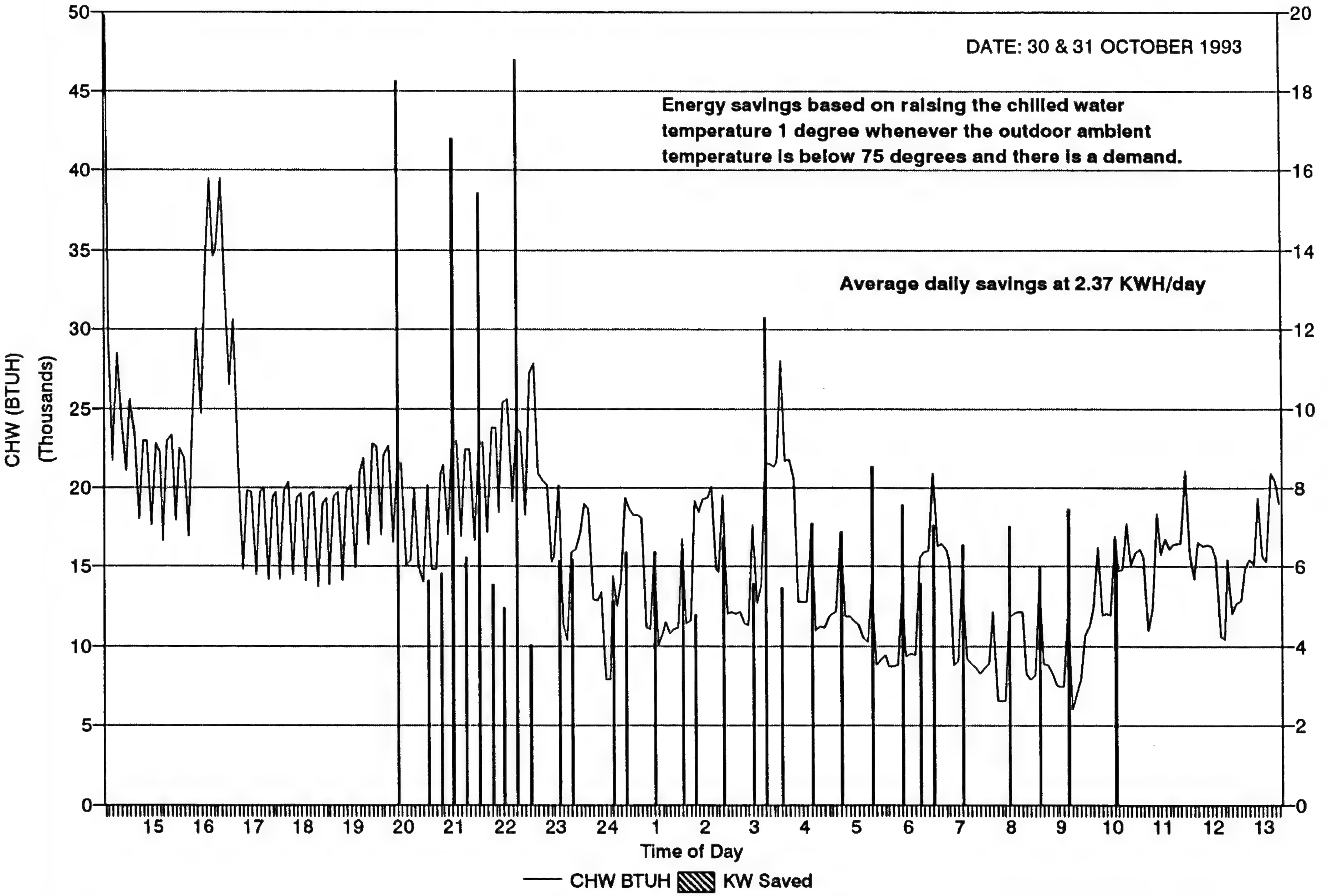
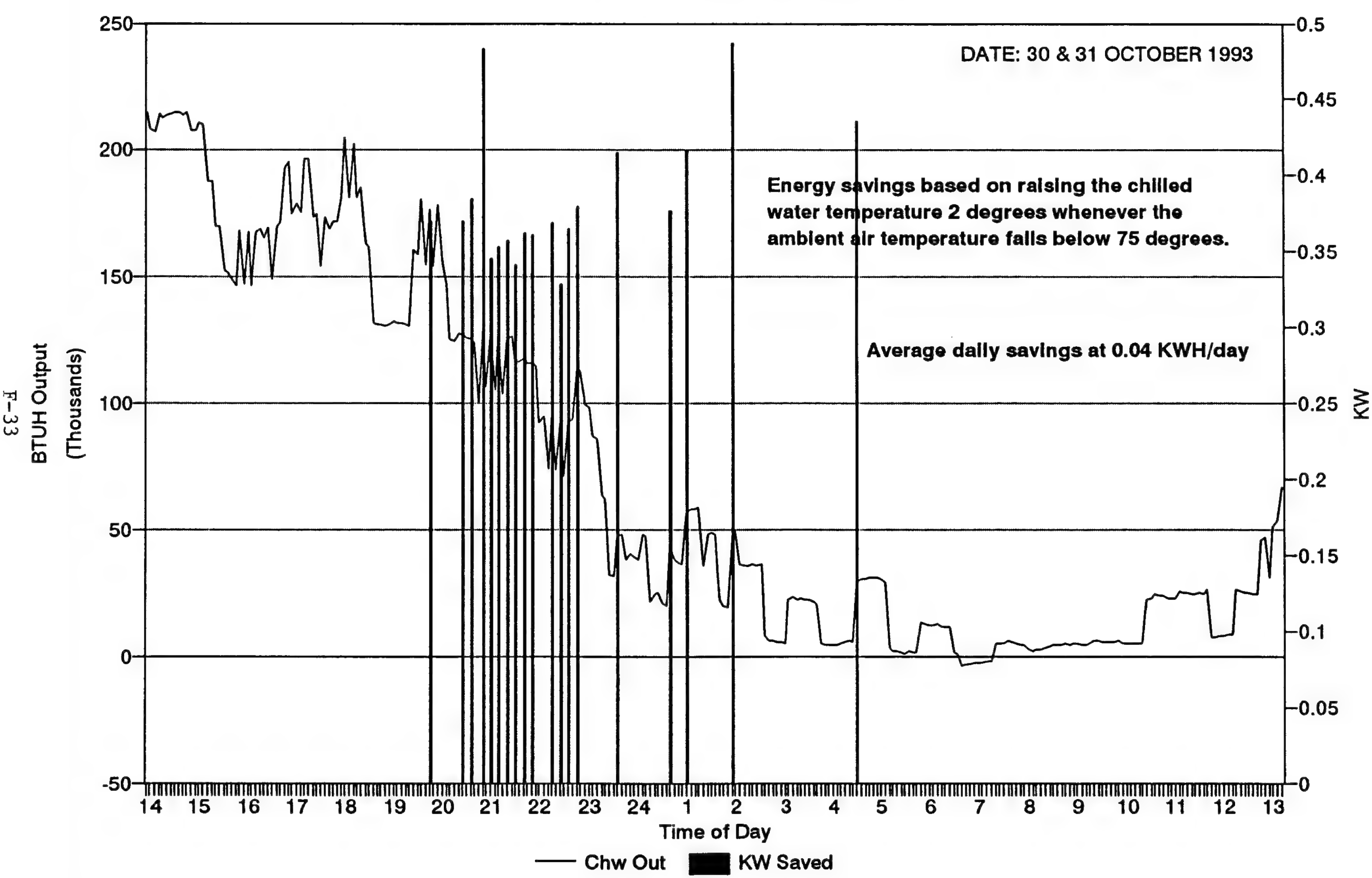


Figure 8: Building 3490 Chiller C-3

100 Ton Air-Cooled Reciprocating



CONSTRUCTION COST ESTIMATE	Date Prepared: January 1994	Sheet 1 Of 1
Project: EEAP Limited Energy Study	Project No.:	Basis for Estimate: Code A (no design competed)
Location: Yuma Proving Ground, Arizona		
Engineer-Architect: Keller & Gannon		
Drawing No.: Chilled Water Reset: Unit Cost Estimate	Estimator: R. Bush	Checked By: B. Horst

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
-							
Chilled Water Reset Package	1	EA.	$995	$995	$4,976	$4,976	$5,971
Package includes temperature sensors, control panel, display panel and field wiring.							
Subtotal				$995		$4,976	$5,971
State Sales Tax	5.5%	%		-		$274	$274
Subtotal							$6,245
Contractor OH & Profit	30.0%	%					$1,873
Subtotal							$8,118
Bond	1.0%	%					$81
Subtotal							$8,199
Estimating Contingency	10.0%	%					$820
Total Probable Construction Cost							$9,019

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Chilled Water Temperature Reset Controls

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Chilled Water Temperature Reset Controls Retrofit Fiscal Year FY96
Discrete Portion Name: Bldg 506 C1and Bldg 2105 C1 & C5 Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 27,057		
B. SIOH	$ 1,623		
C. Design Cost	$ 1,623		
D. Total Cost (1A+1B+1C)	$ 30,304		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$30,304

2. Energy Savings (+)/Cost(-):
Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	146,584	$12,166	11.30	$137,481
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		146584	$12,166		$137,481

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($1,584)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($17,012)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($17,012)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)): 2.86 Years
5. Total Net Discounted Savings (2F5+3C): $120,469
6. Savings to Investment Ratio (SIR) 5/1G: 3.98
7. Adjusted Internal Rate of Return (AIRR): 14.57%

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Chilled Water Temperature Reset Controls

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Chilled Water Temperature Reset Controls Retrofit Fiscal Year FY96
Discrete Portion Name: Bldg 451 Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 9,019		
B. SIOH	$ 541		
C. Design Cost	$ 541		
D. Total Cost (1A+1B+1C)	$ 10,101		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$10,101

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	3,238	$269	11.30	$3,036
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		3238	$269		$3,036

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($528)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($5,671)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($5,671)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	-38.96	Years
5. Total Net Discounted Savings (2F5+3C):	($2,634)	
6. Savings to Investment Ratio (SIR) 5/1G:	-0.26	
7. Adjusted Internal Rate of Return (AIRR):	-195.54%	

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Chilled Water Temperature Reset Controls

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Chilled Water Temperature Reset Controls Retrofit Fiscal Year FY96
Discrete Portion Name: Bldg 506 Chiller 1 (220 Tons) Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 9,019		
B. SIOH	$ 541		
C. Design Cost	$ 541		
D. Total Cost (1A+1B+1C)	$ 10,101		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$10,101

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	105,485	$8,755	11.30	$98,934
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		105485	$8,755		$98,934

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($528)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($5,671)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($5,671)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	1.23	Years
5. Total Net Discounted Savings (2F5+3C):	$93,264	
6. Savings to Investment Ratio (SIR) 5/1G:	9.23	
7. Adjusted Internal Rate of Return (AIRR):	21.19%	

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Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Chilled Water Temperature Reset Controls

Location: Yuma Proving Ground, Arizona Region No. 4 | Project No.
Project Title: Chilled Water Temperature Reset Controls Retrofit | Fiscal Year FY96
Discrete Portion Name: Bldg 2105 Chiller No. 1 | Preparer: KELLER & GANNON
Analysis Date: January 1994 | Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 9,019		
B. SIOH	$ 541		
C. Design Cost	$ 541		
D. Total Cost (1A+1B+1C)	$ 10,101		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$10,101

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	20,550	$1,706	11.30	$19,273
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		20550	$1,706		$19,273

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($528)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($5,671)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($5,671)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	8.58	Years
5. Total Net Discounted Savings (2F5+3C):	$13,603	
6. Savings to Investment Ratio (SIR) 5/1G:	1.35	
7. Adjusted Internal Rate of Return (AIRR):	6.59%	

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Chilled Water Temperature Reset Controls

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Chilled Water Temperature Reset Controls Retrofit Fiscal Year FY96
Discrete Portion Name: Bldg 2105 Chiller No. 2 (40 Tons) Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 9,019		
B. SIOH	$ 541		
C. Design Cost	$ 541		
D. Total Cost (1A+1B+1C)	$ 10,101		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$10,101

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	245	$20	11.30	$229
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		245	$20		$229

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($528)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($5,671)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($5,671)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	-19.90	Years
5. Total Net Discounted Savings (2F5+3C):	($5,441)	
6. Savings to Investment Ratio (SIR) 5/1G:	-0.54	
7. Adjusted Internal Rate of Return (AIRR):	-200.28%	

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Chilled Water Temperature Reset Controls

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Chilled Water Temperature Reset Controls Retrofit Fiscal Year FY96
Discrete Portion Name: Bldg 2105 Chiller No. 5 (125 Tons) Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 9,019		
B. SIOH	$ 541		
C. Design Cost	$ 541		
D. Total Cost (1A+1B+1C)	$ 10,101		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$10,101

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	20,550	$1,706	11.30	$19,273
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		20550	$1,706		$19,273

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($528)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($5,671)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($5,671)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)): 8.58 Years
5. Total Net Discounted Savings (2F5+3C): $13,603
6. Savings to Investment Ratio (SIR) 5/1G: 1.35
7. Adjusted Internal Rate of Return (AIRR): 6.59%

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Chilled Water Temperature Reset Controls

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Chilled Water Temperature Reset Controls Retrofit Fiscal Year FY96
Discrete Portion Name: Bldg 3490 Chiller No. 1 (25 Tons) Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 9,019		
B. SIOH	$ 541		
C. Design Cost	$ 541		
D. Total Cost (1A+1B+1C)	$ 10,101		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$10,101

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	3,862	$321	11.30	$3,622
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		3,862	$321		$3,622

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($528)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($5,671)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($5,671)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)): -48.69 Years
5. Total Net Discounted Savings (2F5+3C): ($2,049)
6. Savings to Investment Ratio (SIR) 5/1G: -0.20
7. Adjusted Internal Rate of Return (AIRR): -193.96%

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Chilled Water Temperature Reset Controls

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Chilled Water Temperature Reset Controls Retrofit Fiscal Year FY96
Discrete Portion Name: Bldg 3490 Chiller No. 2 (50 Tons) Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 9,019		
B. SIOH	$ 541		
C. Design Cost	$ 541		
D. Total Cost (1A+1B+1C)	$ 10,101		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$10,101

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	865	$72	11.30	$811
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		865	$72		$811

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($528)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($5,671)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($5,671)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	-22.14	Years
5. Total Net Discounted Savings (2F5+3C):	($4,859)	
6. Savings to Investment Ratio (SIR) 5/1G:	-0.48	
7. Adjusted Internal Rate of Return (AIRR):	-199.52%	

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Chilled Water Temperature Reset Controls

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Chilled Water Temperature Reset Controls Retrofit Fiscal Year FY96
Discrete Portion Name: Bldg 3490 Chiller No. 3 (100 Tons) Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$ 9,019		
B. SIOH	$ 541		
C. Design Cost	$ 541		
D. Total Cost (1A+1B+1C)	$ 10,101		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$10,101

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	15	$1	11.30	$14
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		15	$1		$14

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($528)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($5,671)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($5,671)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)): -19.18 Years
5. Total Net Discounted Savings (2F5+3C): ($5,657)
6. Savings to Investment Ratio (SIR) 5/1G: -0.56
7. Adjusted Internal Rate of Return (AIRR): -200.54%

Evaporative Precooling of Air-Cooled Chiller Condenser Cooling Air

The possibility of installing indirect evaporative precoolers on air cooled chiller condenser air inlets is investigated. Energy savings are achieved by providing lower temperature air to the condenser coils. This effectively increases both cooling capacity and the Energy Efficiency Ratio. Indirect evaporative coolers are selected, rather than direct evaporative coolers in order to avoid scaling and maintenance problems that could arise with the use of direct application of water to the coils.

The building 451, the Cactus Club, chiller was selected as a test case for the analysis.

Although significant energy savings can be achieved, the required investment exceeds the life cycle energy cost savings. Thus, **this measure is not recommended** as an energy conservation measure.

If it is necessary to increase the capacity of a chiller due to changed loading, for example, this retrofit can raise capacity by about 15 to 20 percent at the height of the summer.

Energy Saving Calculations:

Table 1 provides calculations for energy savings at building 451. Precooling condenser air effectively reduces the condensing air temperature, approaching the wet-bulb temperature. Lower condensing temperatures raise the chiller's Energy Efficiency Ratio (EER), thus, reducing energy requirements for compression.

EER's recorded are from manufacturer's catalog data for an LCWT of 45°F. The first two columns represent design conditions without precooling; the second pair of columns show EER and capacity improvement due to evaporative precooling (PC) of condenser air. Catalog data is from a more recent (higher efficiency model) as catalog data is no longer available for the actual unit installed.

The expression shown below is used to calculate electric energy use for each temperature bin. For purposes of evaluating, it is assumed that the chiller operates at the design capacity of the highest temperature bin, or 42 Tons. The capacity is reduced for lower temperature bins by the ratio of bin temperature difference (Bin outside temperature less design indoor temperature) to the design temperature difference. Both the existing and precooling case power usage are calculated, varying only the EER. Electric energy savings is the difference in power use from these two cases less power requirements of the evaporative cooler.

$$\text{Electric Energy Use (KWH)} = (1 \div \text{EER}) \times \text{KBTUH} \times \text{Hrs} \times (T_{AVG} - T_{ID}) \div (T_{OD} - T_{ID})$$

Where:

EER	Energy Efficiency Ratio (Existing and Precooled Cases)
KBTUH	Capacity of Chiller at Design Conditions (KBTUH)
T_{AVG}	Bin Average Temperature (°F)
T_{OD}	Design Outdoor Temperature (°F)
T_{ID}	Design Indoor Temperature (°F)
Hrs	Hours of occurrence annually for the temperature bins

This approach is very conservative, assuming a continuous cooling load; actual conditions will result in less power consumption because systems are turned off when the Club is not open.

Operation & Maintenance Costs:

O&M costs are not included in this screening analysis because the life-cycle energy cost savings are less than estimated installation costs. Thus, there is no need for further analysis.

Table 1: Evaporative Precooling for Building 451 Air Cooled Chiller

														$0.083	11.30
Bin Weather Data for Yuma, AZ					Note 1	Bldg 451 (Cactus Club) Note 2				Cooling Energy Use		Cooler	Savings	Power Cost Saved	
Lo Deg F	Hi Deg F	Avg Deg F	Hours/Year	MCWB	Precool db	EER @ DB	Cap Tons	EER @ PC	Cap Tons	Extg kWH	Futr kWH	Fan kWH	kWH/Year	($/Yr)	(LCC $)
120	124	122	0	72	97.0	7.7	42.0	10.3	49.8	0	0	0	0	$0	$0
115	119	117	3	72	94.5	8.2	43.6	10.5	50.3	164	128	(4)	32	$3	$30
110	114	112	50	72	92.0	8.6	45.1	10.9	51.3	2,256	1,790	(72)	393	$33	$369
105	109	107	229	71	89.0	9.2	46.7	11.3	52.2	8,312	6,736	(332)	1,245	$103	$1,167
100	104	102	398	71	86.5	9.7	48.2	11.6	52.8	11,312	9,454	(577)	1,282	$106	$1,202
95	99	97	512	69	83.0	10.3	49.8	12.1	54.0	10,846	9,185	(742)	918	$76	$861
90	94	92	641	67	79.5	10.9	51.3	12.7	55.4	9,451	8,079	(929)	443	$37	$416
85	89	87	845	66	76.5	11.6	52.8	13.0	56.1	7,527	6,699	(1,224)	(397)	($33)	($372)
80	84	82	829	63	72.5	12.3	54.3	13.2	56.6	3,095	2,878	(1,201)	(983)	($82)	($922)
75	79	77	761	58	67.5	13.0	56.1	13.5	57.3	670	646	(1,103)	(1,078)	($89)	($1,011)
70	74	72	784	55	63.5	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
65	69	67	815	52	59.5	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
60	64	62	802	49	55.5	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
55	59	57	777	46	51.5	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
50	54	52	638	43	47.5	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
45	49	47	412	40	43.5	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
40	44	42	182	36	39.0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
35	39	37	55	31	34.0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
30	34	32	10	27	29.5	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
25	29	27	0	22	24.5	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
Totals			8,743							53,633	45,594	(6,184)	1,854	$154	$1,739

PROJECT NOT RECOMMENDED: LCC SAVINGS IS LESS THAN CONSTRUCTION COST.

Notes:

1. Per manufacturer, indirect evaporative precooling is 50% efficient, thus, new dry bulb (db) temperature to condenser coils will be: Actual db - (0.5 x Delta T db-wb).

2. EER's recorded are from manufacturer's catalog data for an LCWT of 45 Deg F. The first two columns represent design conditions without precooling; the second pair of columns show EER and capacity improvement due to evaporative precooling (PC) of condenser air. Catalog data is from a more recent (higher efficiency model) as catalog data is no longer available for the actual unit installed.

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1 Of 1

Project **EEAP Limited Energy Study**	Project No.	Basis for Estimate **Code A (no design competed)**
Location **Yuma Proving Ground, Arizona**		
Engineer-Architect **Keller & Gannon**		
Drawing No.	Estimator **BIH**	Checked By **RCL**

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Indirect Evaporative Precooling of Condenser Cooling Air - Building 451							
Arvin IM660A Indirect Precooler	3	EA	$594	$1,781	$1,200	$3,600	$5,381
Water Piping, allowance	-	Lot	-	$1,000	-	$200	$1,200
Power Supply, allowance	-	Lot	-	$500	-	$100	$600
Subtotal				$3,281		$3,900	$7,181
State Sales Tax	5.5%	%				$215	$215
Subtotal							$7,396
Contractor OH & Profit	30.0%	%					$2,219
Subtotal							$9,615
Bond	1.0%	%					$96
Subtotal							$9,711
Estimating Contingency	10.0%	%					$971
Total Probable Construction Cost							$10,682

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Evaporative Precooling Retrofit

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Evaporative Precooling of Air Cooled Condensers Fiscal Year FY96
Discrete Portion Name: Building 451 Test Case Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$10,682		
B. SIOH	$ 641		
C. Design Cost	$ 641		
D. Total Cost (1A+1B+1C)	$ 11,964		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$11,964

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	1,854	$154	11.30	$1,739
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		1854	$154		$1,739

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	$0		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			$0

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) $0

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	77.73	Years
5. Total Net Discounted Savings (2F5+3C):	$1,739	
6. Savings to Investment Ratio (SIR) 5/1G:	0.15	
7. Adjusted Internal Rate of Return (AIRR):	-8.11%	

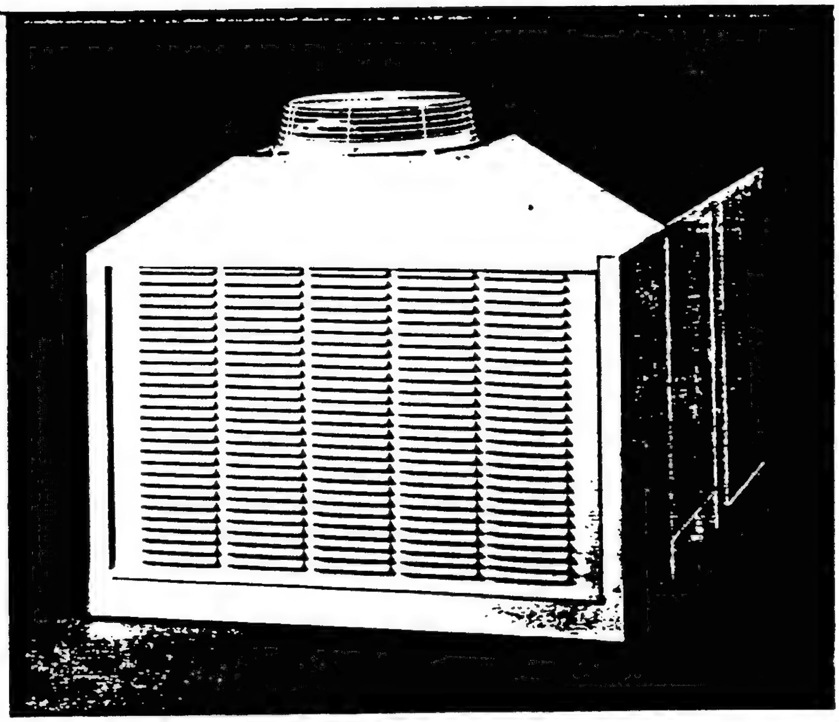
Arvin
THE LEADER IN ENERGY-EFFICIENT COOLING

ArvinAir Division
Arvin Industries, Inc.
500 South 15th Street
Phoenix, Arizona 85034

MODEL NUMBER

IM450A/460A & IM650A/660A

MASTERCOOL 2-STAGE



THE BREAKTHROUGH IN AFFORDABLE COOLING.

DESIGN

The Indirect Cooling Module can be attached to an Arvin MasterCool evaporative cooler to provide a 2-Stage cooling system. Though this combination will be the most common configuration, the Indirect Cooling Module can also be used separately where substantial outside air is required for air conditioning systems.

APPLICATIONS

MasterCool 2-Stage is recommended for cooling homes and for a variety of commercial applications. The cooling power of MasterCool 2-Stage exceeds that of standard evaporative coolers and is less affected by higher ambient temperature and humidity. The unit has special value where there is a requirement for colder air or greater comfort than can be provided by a standard evaporative cooler. This is accomplished with electricity savings of 80% compared to air conditioning.

Used without a MasterCool, the Indirect Cooling Module can economically reduce the temperature without adding moisture on air conditioning installations where significant make-up air is required.

Materials made to last.

GALVANIZED STEEL

This Arvin unit is constructed of hot-dipped, galvanized steel, welded for maximum strength.

POLYBOND™ an Arvin exclusive

POLYBOND coating is an attractive, appliance-like finish that protects the whole system—cabinet pans, louvers, and all other parts contacting water. The electrostatically-applied, polyester-epoxy coating is cured at high temperature and will not chip, peel, corrode or rust. The POLYBOND finish is so durable that this model is backed with a five-year warranty.

HEAT EXCHANGER

The patented polystyrene heat exchanger in the Indirect Cooling Module is designed to cool the air without adding moisture. The heat exchanger is expected to last up to 10 years.

CONSTRUCTION

Every Arvin unit is engineered and constructed for reliability with precision made componentry, UL recognized motor and pump, and unique water distribution system to assure uniform wet-out of the heat exchanger.

MAINTENANCE

The Indirect Cooling Module requires very little maintenance since it contains no pads to replace and does not require undercoating.

ACCESSORIES

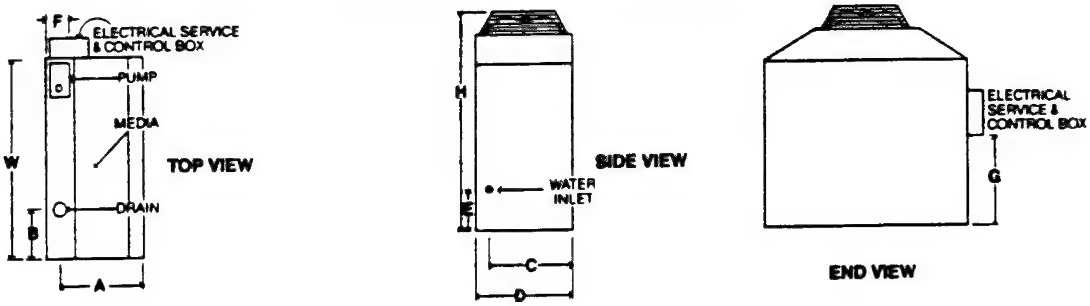
Arvin provides a complete line of installation aids and accessories. Refer to the Arvin Replacement Parts Catalog or your sales representative.

Arvin
THE LEADER IN ENERGY-EFFICIENT COOLING

ArvinAir Division
Arvin Industries, Inc.
500 South 15th Street
Phoenix, Arizona 85034

MODEL NUMBER
IM450A/460A & IM650A/660A
MASTERCOOL 2-STAGE

IM450A/460A and IM650A/660A



DIMENSIONS

Model Number	Cabinet			Drain Location		Water Service Location		Electrical Service & Control Box		Weights	
	H	W	D	A	B	C	E	F	G	Shipping	Operating
IM450A/460A	38	42	17	14½	11½	14½	5	5	15	155	250
IM650A/660A	43	42	17	14½	11½	14½	5	5	20	165	265

SPECIFICATIONS

Model Number	Electrical Specifications				Bleed-off Rate GPH	Pump		
	HP	Phase	Volts	Amps		Part no.	GPM	Head (ft.)
IM450A	⅕	1	115	4.1	4.5	A400109A	5.0	5
IM460A	⅕	1	230	2.1	4.5	A400107A	5.0	5
IM650A	⅕	1	115	4.1	5.6	A400109A	5.0	5
IM660A	⅕	1	230	2.1	5.6	A400107A	5.0	5

SIZING

For accurate sizing information, please consult your local sales representative.

[illegible]

Duty Cycling Controls

Installing a programmable controller to turn off the chillers 10 minutes per hour during peak electrical demand periods will save demand and penalty charges by the Western Area Power Authority (WAPA). Yuma Proving Ground is charged $1.98 per kW-Month. This is a very low demand charge compared to commercially available power supplies, however, a penalty of 10 times this rate is charged whenever power demand exceeds YPG's allocation. The allocation is presently exceeded several times per year. Energy cost savings, thus, assume one excursion per year.

All chiller systems surveyed were considered; only two buildings' chiller systems are included: building 451, the Cactus Club and building 3490, the Test Evaluation Facility.

Building 506, the Enlisted Persons Barracks, is excluded from this project because its chiller system is already fitted with an electrical demand limiting system: the Ice-On-Coil system. The Ice-On-Coil system operates in recovery mode (cooling from stored ice) during the peak electrical demand period; no compressors are normally operated during these periods.

Building 2105, the Range Operations Center is not included because it houses critical mission operations consisting of extensive computer systems. Additionally, the building cooling system is served by a solar-assisted absorption cooling system which is operated during the peak demand periods.

Building 3482, the Test Preparation Facility, is an explosives assembly building and must have uninterrupted air conditioning services for safety reasons. Building 3510 is an Explosives Storage Magazine and must have uninterrupted air conditioning service for the same reason. These buildings are not included in the duty cycling control project.

Calculations result in an SIR of just less than 1 for Building 451. However, combined with the results of a similar analysis for building 3490, the overall SIR is 1.36. The retrofit is recommended for installation to allow future connection to a basewide EMCS; all building chillers not servicing critical mission requirements will have to be connected to such a load shedding system.

Energy Savings Calculation:

This project is designed to reduce charges for electrical demand during peak cost periods. No energy savings are achieved by turning chillers off for short periods, since system controls will force the chillers to "make-up" the load when they are operating. The chiller's connected load is divided by "6" to determine demand kW reduction. Calculations are provided on Table 1. The cost savings basis is addressed on Table 1.

Operations & Maintenance Costs:

It is assumed that O&M on each new control system will require 2 hours of maintenance annually. A labor rate of $22 per hour, plus 50% overhead and fringe benefits is assumed.

TABLE 1: SUMMARY OF CHILLER DUTY CYCLING CONTROLS RETROFIT CALCULATIONS

APS $1.98 per month/kW

Bldg No.	Unit Description	Capacity (Tons)	Manufacturer	Refrigerant	Chiller Load kW	Source/Reason	Energy Savings kW	Energy Savings $/Year	Energy Savings LCC $ (11.3)	O&M Savings $/Year	O&M Savings LCC $ (10.74)	Total Savings $/Year	Total Savings LCC $	Controls Investment	onomic Measures SIR	onomic Measures Payback
451	A/C Reciprocating	55	Carrier	R-22, 136 lbs.	64.02	Catalog	10.7	$338	$3,820	($66)	($709)	$272	$3,111	$2,554	1.22	9.39
506	W/C Centrifugal	220	Trane	R-11, 450 lbs.	NA	Bldg has demand	-	-	-	-	-	-	-	-	-	-
506	A/C Recip. - Glycol (1)	36	Trane	R-22 (Rebuilt)	NA	limiting system	-	-	-	-	-	-	-	-	-	-
2105	C-1 W/C Centrifugal	125	Trane	R-113, 415 lbs.	NA	Bldg houses	-	-	-	-	-	-	-	-	-	-
2105	C-2 W/C Reciprocating	40	Trane	R-22, 55 lbs.	NA	critical mission	-	-	-	-	-	-	-	-	-	-
2105	C-5 W/C Centrifugal	125	Carrier	R-11	NA	activities	-	-	-	-	-	-	-	-	-	-
3482	W/C Reciprocating - DX	62	Carrier	R-22	NA	Safety	-	-	-	-	-	-	-	-	-	-
3490	C-1 A/C Reciprocating	25	Webster	R-22	21.3	Catalog	3.6									
3490	C-2 A/C Reciprocating	50	Webster	R-22	42.1	Catalog	7.0	$826	$9,337	($66)	($709)	$760	$8,629	$3,970	2.17	5.22
3490	C-3 A/C Reciprocating	100	Webster	R-22	93.1	Catalog	15.5									
3510	W/C Reciprocating - DX	40	Trane	HFC-134a (Note 2)	NA	Safety	-	-	-	-	-	-	-	-		
Totals							36.8	$1,164	$13,157	($132)	($1,418)	$1,032	$11,739	$6,524	1.80	6.32

A/C Air Cooled
W/C Water Cooled
DX Direct Expansion Unit

Additional O&M costs assume 2 hours maintenance per year at $22/MH x 1.5 for OH & fringes

Demand charge savings are based on WAPA demand charge of $1.98/kW-Mo and a penalty equal to 10 times this rate (usually experienced once or twice a year). Cost savings based on avoiding a single such occurance each year.

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1 Of 1
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: Code A (no design competed)
Location: Yuma Proving Ground, Arizona		
Engineer-Architect: Keller & Gannon		
Drawing No.	Estimator: BIH	Checked By: RCL

Line Item	Quantity No. Units	Quantity Unit Meas.	Labor Per Unit	Labor Total	Material Per Unit	Material Total	Total Cost
Building 451 (1 Chiller)							
Programable Controller	1	EA	$350	$350	$750	$750	$1,100
Digital Output Point W/Wiring	1	EA	$100	$100	$320	$320	$420
Subtotal				$450		$1,070	$1,520
State Sales Tax	5.5%	%		-		$59	$59
Subtotal							$1,579
Contractor OH & Profit	30.0%	%					$474
Subtotal							$2,053
Bond	1.0%	%					$21
Subtotal							$2,073
Estimating Contingency	10.0%	%					$207
Total Probable Construction Cost							$2,280
Building 3490 (3 Chillers)							
Programable Controller	1	EA	$350	$350	$750	$750	$1,100
Digital Output Point W/Wiring	3	EA	$100	$300	$320	$960	$1,260
Subtotal				$650		$1,710	$2,360
State Sales Tax	5.5%	%		-		$94	$94
Subtotal							$2,454
Contractor OH & Profit	30.0%	%					$736
Subtotal							$3,190
Bond	1.0%	%					$32
Subtotal							$3,222
Estimating Contingency	10.0%	%					$322
Total Probable Construction Cost							$3,544

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Buildings 451 & 3490

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Chiller Study Fiscal Year FY96
Discrete Portion Name: Demand Limit Chillers Serving Buildings 451 & 3490
Analysis Date: January 1994 Economic Life: 15 YEARS Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	$5,825		
B. SIOH	$349		
C. Design Cost	$349		
D. Total Cost (1A+1B+1C)	$6,524		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$6,524

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH/(1)	Saving KWH/YR(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	0.0	$0	11.30	$0
B. Dist					
C. Propane					
D. Other					
E. Demand Savings	$1.98/kW-Mo	36.8	$1,164	11.30	$13,157
F. Total	Based on $1.98/kW-Mo @ 6 Months + 10 times rate for 1 Mo.		$1,164		$13,157

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($132)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($1,418)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Doscounted Sav-ings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($1,418)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	6.32	Years
5. Total Net Discounted Savings (2F5+3C):	$11,739	
6. Savings to Investment Ratio (SIR) 5/1G:	1.80	
7. Adjusted Internal Rate of Return (AIRR):	8.67%	

Optimal Cooling Tower Control

Optimal or near-optimal control of cooling towers for water cooled systems is considered for energy conservation at buildings 3482 and 3510. The option presents an algorithm for near-optimal control for cooling towers. The algorithm is based on an open-loop control equation in terms of the total cooling load. The parameters of this equation may be estimated from design data with relations derived from a simple model for cooling tower and compressor power trade-offs with tower control. Results of the near-optimal control algorithm would be compared with the "true" optimal solution applied to a detailed simulation model. Equations used for this type of analysis are as follows:

$$G_{twr} = 1 - \beta_{twr}(PLR_{twr}, cp - PLR) \quad (1)$$

$$G_{twr} = 4PLR\ [1 - \beta_{twr}(PLR_{twr}, cp - 0.25) \quad (2)$$

Where:

G_{twr}	Tower airflow divided by the maximum airflow with all cells operating at high speed
PLR	Compressor load divided by the total cooling capacity (part load ratio).
PLR_{twr}, cp	The part load ratio (value of PLR) at which tower operates at its capacity.
β_{twr}	Slope of the relative tower airflow vs. part load ratio function.

With the parameters of equation (1) specified, the following algorithm is applied at each decision interval (e.g., 15 minutes) in order to determine the tower control:

1. If the temperature of the supply water to the condenser is less then the low limit, then reduce the tower airflow by one increment according to the optimal sequencing rules and exit the algorithm. Otherwise, go to step 2.

2. If the temperature of the supply water to the condenser is greater then the high limit, then increase the tower airflow by one increment according to the optimal sequencing rules and exit the algorithm. Otherwise, go to step 3.

3. Determine the cooling load relative to the design load.

4. If the cooling load has changed by a significant amount (e.g., 10%) since the last control change, then go to step 5; otherwise, exit the algorithm.

5. If the part load ratio is greater then 0.25, then compute the tower airflow as a fraction of the tower capacity with equation (1). Otherwise compute G_{twr} with equation (2).

6. Restrict the value of G_{twr} between 0 and 1.

7. Convert the value of G_{twr} to a specific set of control functions to each of the tower cell fans according to the optimal sequencing rules.

This type of energy conservation method is designed for much larger systems than the DX coils at either buildings 3482 or 3510. Although the concept is worthy of study for large, complex systems, it would not be practical for the towers to be controlled only by the 62 Ton or 40 Ton systems. Thus, the model was not implemented.

Electronic Expansion Valve Retrofit on DX Units

Two of the cooling study buildings have air handling systems providing space cooling via direct expansion (DX) cooling coils.

Replacement of the existing thermostatic expansion valves with electronically controlled expansion valves is considered for building 3482, Test Preparation Facility, and for building 3510, Munitions Storage Magazine.

Electronic expansion valves reduce refrigerant system pressure to the minimum required for refrigerant phase change. This reduced system pressure means that the compressor motor does not need to work as hard for the system to still produce the required cooling. Thus, energy savings are achieved.

Because of the control system feedback necessary for modulating the expansion valves, the devices are only effective when used in conjunction with a direct digital control (DDC) system. At present, these buildings are not fitted with DDC controls. Any energy savings realized by the installation of electronic expansion valves and associated DDC systems would be more than offset by the high first cost of the required DDC control control system.

Thus, this option was disregarded as a possible energy saving opportunity since potential cost savings could not compensate for the high cost of DDC controls.

Manifold Building 3490 Chillers

Building 3490, Test Evaluation Facility, is provided space cooling by three (3) air cooled chillers serving air handling units. Each of the chillers serve different parts of the building. During low load periods all three chiller systems operate near their minimum efficiencies with significant unloading.

Installation of piping and controls to combine the three systems into a single system will allow low load conditions to be served by only one or two compressors operating near their rated capacities. Energy savings will result because compressors operate more efficiently at rated capacities than in unloaded conditions.

Replacing the rooftop cooling unit serving the Electronics Room in the Gun Shop with a chilled water fan coil unit will save additional energy.

Energy Saving Calculations:

Data collected for about a 24 hour period in October 1993:

- Cooling load measurements - BTUH of chilled water from each chiller
- kW Power consumption measurements - for each chiller
- Outside dry-bulb air temperature measurements
- Manufacture's data on chillers and compressors

Assumptions:

1. Chillers operate at peak capacity during hottest observed temperatures in TM 5-785 Bin data.
2. For peak temperature operations, chiller performance data at 105 °F dry-bulb applies.
3. Measured performance data (power use and thermal load) applies to measured outdoor temperatures.

Existing System Annual Power Usage Estimate

Chillers are manufactured by Webster, now out of business. Available catalog data lists the following for 105°F and 45°F LWT; Copeland compressor data for 50% loading:

Chiller	Model	Unloading	Tons	kW	100% EER	50% EER
Chiller 1	CPK-26A	100, 50, 0	17.6	21.3	9.92	9.23
Chiller 2	CPK-51A	100,75,50,25,0	35.1	42.1	10.00	9.31
Chiller 3	CPK-100A2	100,75,50,25,0	66.5	93.1	8.57	7.98

Chillers are loaded as shown on Figures 1 and 2. Existing energy usage is determined based on measurements:

Measurement period power usage by Chillers 1, 2 and 3:	860	kWH (see Table 1)
Measurement period Cooling Degree-Hours:	252	Degree-Hours (see Table 1)
Annual Cooling Degree-Hours from TM 5-785 Bin Data:	109,474	Degree-Hours (see Table 2)

Estimated annual power use of existing Chillers 1, 2 & 3:
Measurement Period kWH x Annual Deg-Hours ÷ Measurement Period Deg-Hours = **373,923 kWH/Year**

Estimated annual power usage of Electronics Room Rooftop type cooling unit:

Unit size, about 5 Tons, energized continuously = **43,800 kWH/Year**

Proposed System Annual Power Usage Estimate

The proposed system of manifolding chillers will provide for operations usually near one of the chiller's full load operating point, thus, more efficiently. Based on manufacturer data for full load operation at each of the temperature bins, future energy consumption is estimated at:

Outside Air Temp	Total Chiller kW	Bin Hours /Year	Cooling kWH/Yr	Remarks
105	158.9	282	44,810	Maximum load, all chillers at 100%
100	133.1	398	52,954	Chiller 1 off, Chillers 2 & 3 at 100%
95	110.5	512	56,576	Chiller 2 off, Chillers 1 & 3 at 100%
90	65.9	641	42,258	Chillers 1 & 2 off, Chiller 3 on 75%
85	53.8	845	45,419	Chillers 2 off, Chillers 1 & 3 at 50%.
80	41.9	829	34,735	Chillers 1 & 3 off, Chiller 2 at 100%.
75	30.1	761	22,887	Chillers 1 & 3 off, Chiller 2 at 75%
70	21.2	784	16,621	Chillers 2 & 3 off, Chiller 1 at 100%
65	10.6	815	8,639	Chillers 2 & 3 off, Chiller 1 at 50%
60	0.0	802	-	
Total			**324,898**	**kWh/Year**

Savings from replacing Gun Shop Electronics Room Rooftop type Cooling Unit:

43,800 kWh/Year

Total Savings = 92,825 kWh/Year $ 0.083 /kWH = $ 7,704 /Year

Operations & Maintenance Costs:

Manifolding of chillers involves installation of controls, piping and fittings, including control valves. Annual O&M labor to maintain these additional building components is estimated to require about 40 MH. Assuming a labor rate of $22 per hour, plus 50% for overhead and fringe benefits, additional yearly O&M cost is:

40 MH x $22 /MH x 1.5 = $ 1,320 per year added O&M cost

Economic Evaluation Results:

This option was found cost effective with a payback period of about 9 years, a savings to investment ratio of 1.27 and an internal rate of return of 6.19%.

Figure 1: Building 3490 Chiller Loading

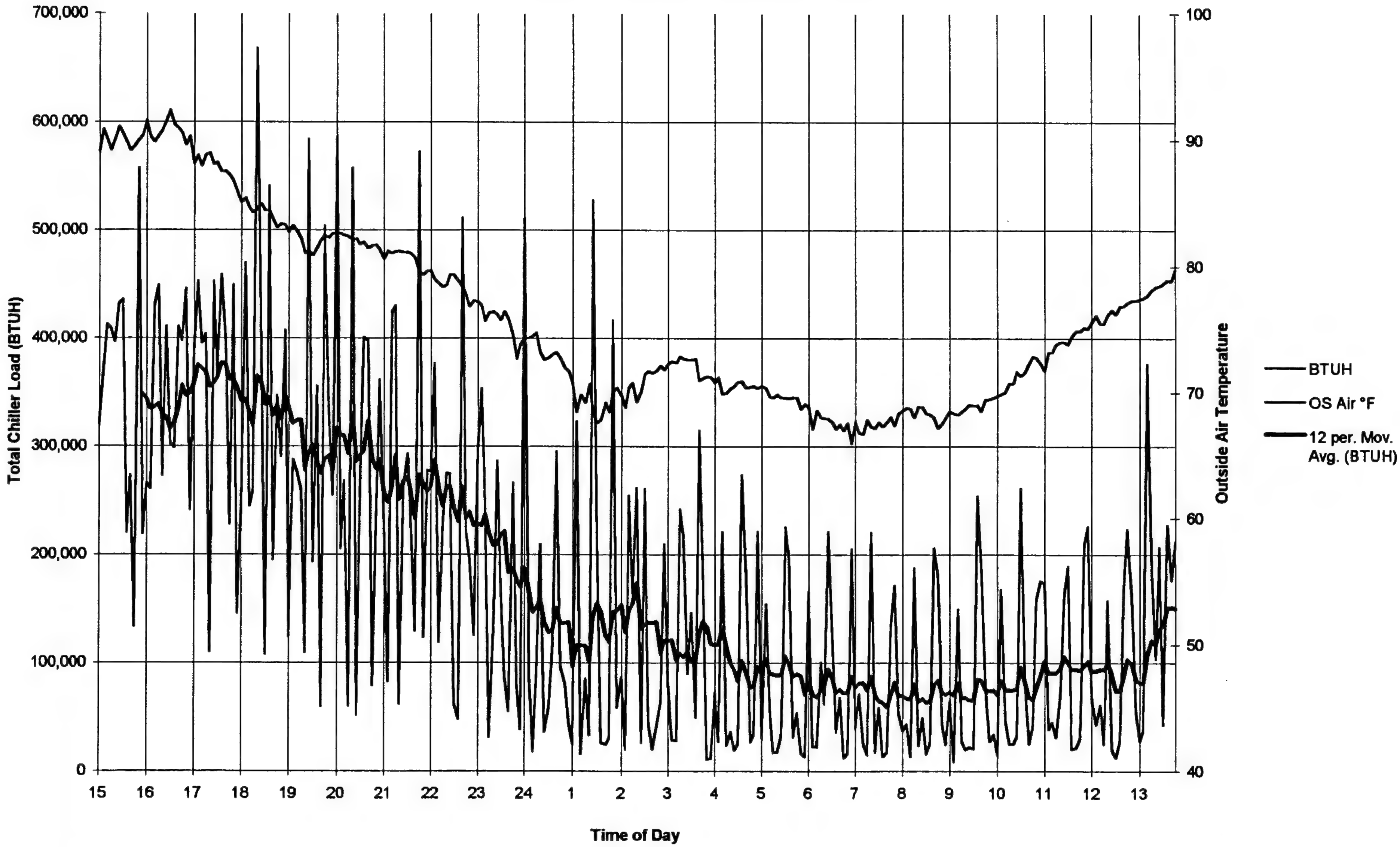


Figure 2: Chiller kW Load vs Temperature
Three Chillers Operating

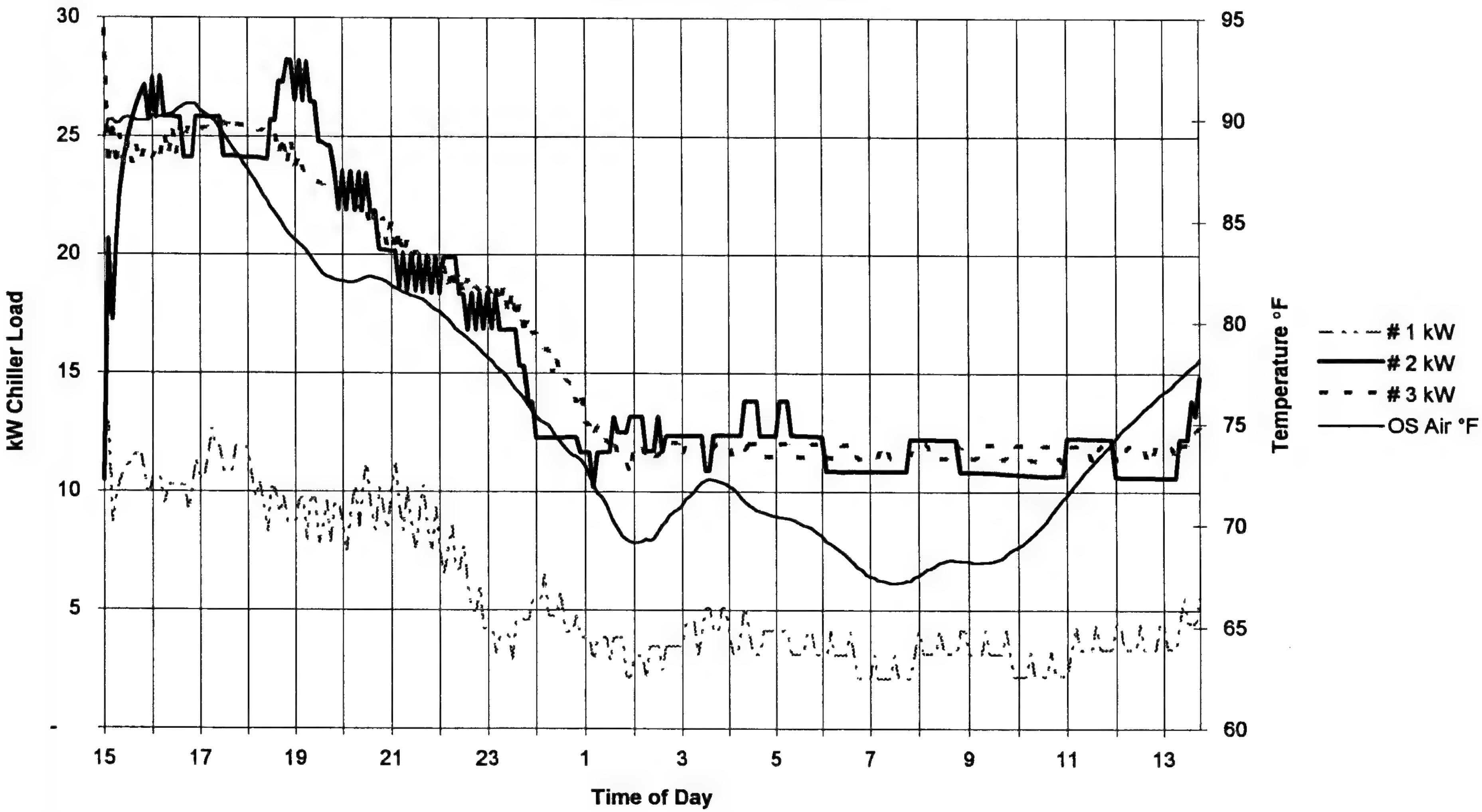


Table 1: Measured Performance Data: Building 3490 Chillers

Measurement Time					Chiller 1		Chiller 2		Chiller 3			Running Hourly Average BTUH / kWH for Chillers						Total
Day	Month	Yr	Hr	Min	BTUH	KW	BTUH	KW	BTUH	KW	OS Air °F	# 1 BTUH	# 1 kW	# 2 BTUH	# 2 kW	# 3 BTUH	# 3 kW	kWH
31	Oct.	93	14	35	54,515	13	52,616	10	213,421	30	89.1	54,515	13	52,616	10	213,421	30	4.4
31	Oct.	93	14	40	168,636	13	7,731	31	192,669	18	90.8	111,576	13	30,174	21	203,045	24	4.8
31	Oct.	93	14	45	190,830	0	6,888	10	215,138	30	90.0	137,994	9	22,412	17	207,076	26	4.3
31	Oct.	93	14	50	181,909	13	48,696	31	178,635	17	89.2	148,973	10	28,983	21	199,966	24	4.5
31	Oct.	93	14	55	184,409	13	6,742	31	205,583	31	90.1	156,060	10	24,535	23	201,089	25	4.8
31	Oct.	93	15	0	183,150	13	5,863	31	243,505	17	91.1	160,575	11	21,423	24	208,159	24	4.9
31	Oct.	93	15	5	176,963	13	47,596	31	210,883	31	90.5	162,916	11	25,162	25	208,548	25	5.1
31	Oct.	93	15	10	177,089	13	1,832	31	41,057	17	89.8	164,688	11	22,246	26	187,612	24	5.1
31	Oct.	93	15	15	51,476	13	7,914	31	213,272	31	89.1	152,109	12	20,653	26	190,463	25	5.2
31	Oct.	93	15	20	22,374	13	58,369	31	53,075	17	89.5	139,135	12	24,425	27	176,724	24	5.2
31	Oct.	93	15	25	334,160	0	9,820	31	213,048	31	90.0	156,865	11	23,097	27	180,026	25	5.2
31	Oct.	93	15	30	176,729	0	4,873	11	37,175	19	90.3	158,520	10	21,578	26	168,122	24	5.0
31	Oct.	93	15	35	19,191	23	43,676	31	202,971	29	91.5	155,577	11	20,833	27	167,251	24	5.2
31	Oct.	93	15	40	40,306	13	1,026	10	219,319	23	90.3	144,882	11	20,275	26	169,472	25	5.1
31	Oct.	93	15	45	229,824	0	7,914	31	192,744	25	89.8	148,132	11	20,360	28	167,606	24	5.2
31	Oct.	93	15	50	168,276	0	64,964	10	215,362	29	90.3	146,996	9	21,716	26	170,666	25	5.0
31	Oct.	93	15	55	179,427	23	49,978	31	43,222	19	90.8	146,581	10	25,319	26	157,136	24	5.0
31	Oct.	93	16	0	178,510	13	15,462	31	216,781	31	91.5	146,194	10	26,119	26	154,909	25	5.1
31	Oct.	93	16	5	176,586	13	83,101	30	43,296	18	92.3	146,162	10	29,078	26	140,944	24	5.0
31	Oct.	93	16	10	42,285	13	49,758	31	206,628	31	91.2	134,929	10	33,071	26	154,741	25	5.1
31	Oct.	93	16	15	190,489	13	4,873	10	215,064	24	90.9	146,513	10	32,818	24	154,890	25	4.9
31	Oct.	93	16	20	204,284	0	4,873	31	188,414	25	90.5	161,672	9	28,360	24	166,169	25	4.9
31	Oct.	93	16	25	175,776	13	42,943	31	226,858	31	89.6	148,474	10	31,120	24	167,320	25	5.0
31	Oct.	93	16	30	181,226	13	6,705	31	53,150	18	90.3	148,848	11	31,273	26	168,651	25	5.2
31	Oct.	93	16	35	176,747	13	3,847	31	209,166	31	88.1	161,978	11	27,954	26	169,167	25	5.2
31	Oct.	93	16	40	174,409	13	48,915	10	229,098	22	88.7	173,153	11	31,945	26	169,982	25	5.1
31	Oct.	93	16	45	175,398	13	3,884	31	216,034	27	87.9	168,618	12	31,609	26	171,923	25	5.2
31	Oct.	93	16	50	176,136	13	2,858	10	224,768	31	88.8	169,273	13	26,433	26	172,707	26	5.3
31	Oct.	93	16	55	12,464	13	44,812	31	53,075	18	89.0	155,359	12	26,003	26	173,528	25	5.3
31	Oct.	93	17	0	229,140	13	4,067	31	218,722	31	88.0	159,578	12	25,053	26	173,690	26	5.3
31	Oct.	93	17	5	166,927	0	843	10	197,671	19	88.2	158,774	11	18,198	24	186,554	26	5.0
31	Oct.	93	17	10	183,078	13	48,842	31	226,186	30	87.5	170,506	11	18,122	24	188,184	25	5.0
31	Oct.	93	17	15	184,104	13	5,679	10	209,092	28	87.5	169,974	11	18,189	24	187,686	26	5.1
31	Oct.	93	17	20	179,769	13	2,821	31	45,237	21	87.2	167,931	12	18,018	24	175,755	25	5.1
31	Oct.	93	17	25	180,920	13	45,764	31	222,529	31	86.7	168,360	12	18,253	24	175,394	25	5.1
31	Oct.	93	17	30	79,947	13	4,910	31	60,914	17	85.9	159,920	12	18,104	24	176,041	25	5.1
31	Oct.	93	17	35	32,734	13	1,026	31	210,659	31	85.1	147,919	12	17,868	24	176,165	25	5.1

Table 1: Measured Performance Data: Building 3490 Chillers

Measurement Time					Chiller 1		Chiller 2		Chiller 3			Running Hourly Average BTUH / kWH for Chillers						Total
Day	Month	Yr	Hr	Min	BTUH	KW	BTUH	KW	BTUH	KW	OS Air °F	# 1 BTUH	# 1 kW	# 2 BTUH	# 2 kW	# 3 BTUH	# 3 kW	kWH
31	Oct.	93	17	40	240,885	0	48,842	11	179,829	22	85.4	153,459	11	17,862	24	172,060	26	5.0
31	Oct.	93	17	45	17,698	0	4,910	31	222,006	26	84.6	140,317	10	17,948	24	172,557	25	4.9
31	Oct.	93	17	50	29,515	21	2,015	11	226,933	28	84.2	128,099	10	17,878	24	172,738	25	5.0
31	Oct.	93	17	55	337,577	0	44,922	31	284,786	20	84.5	155,191	9	17,887	24	192,047	25	4.9
31	Oct.	93	18	0	151,963	0	4,910	31	230,815	31	84.9	148,760	8	17,957	24	193,055	25	4.8
31	Oct.	93	18	5	69,138	23	1,795	31	36,951	17	84.4	140,611	10	18,036	26	179,661	25	5.1
31	Oct.	93	18	10	264,141	13	47,706	31	228,725	30	84.5	147,366	10	17,942	26	179,873	25	5.1
31	Oct.	93	18	15	153,294	0	2,821	30	39,041	16	83.7	144,798	9	17,704	27	165,702	24	5.0
31	Oct.	93	18	20	131,027	22	1,026	30	214,616	30	83.1	140,737	10	17,554	27	179,817	25	5.2
31	Oct.	93	18	25	200,471	0	46,644	42	43,147	16	83.4	142,366	9	17,627	28	164,869	24	5.1
31	Oct.	93	18	30	183,708	12	4,910	30	218,647	30	83.3	151,013	9	17,627	28	178,013	25	5.1
31	Oct.	93	18	35	82,196	13	1,026	11	41,057	17	82.7	155,134	9	17,627	27	163,879	24	4.9
31	Oct.	93	18	40	10,432	12	49,685	30	226,933	29	83.2	135,930	10	17,697	28	167,805	24	5.2
31	Oct.	93	18	45	233,187	0	3,884	11	39,041	18	82.8	153,887	10	17,612	26	152,558	24	5.0
31	Oct.	93	18	50	32,051	0	2,821	30	224,544	28	82.1	154,099	8	17,679	28	152,359	24	5.0
31	Oct.	93	18	55	19,029	21	47,633	11	43,072	17	81.0	127,553	10	17,905	26	132,216	23	5.0
31	Oct.	93	19	0	358,135	0	4,690	30	220,886	28	81.3	144,734	10	17,887	26	131,388	23	4.9
31	Oct.	93	19	5	147,448	0	4,873	11	41,057	16	80.9	151,260	8	18,143	25	131,731	23	4.6
31	Oct.	93	19	10	83,077	22	53,459	30	218,871	30	81.4	136,171	9	18,623	25	130,909	23	4.7
31	Oct.	93	19	15	18,454	12	7,951	29	33,667	15	82.1	124,935	10	19,050	25	130,462	23	4.8
31	Oct.	93	19	20	272,702	0	5,863	30	225,141	30	82.4	136,741	8	19,453	25	131,339	23	4.6
31	Oct.	93	19	25	2,410	20	55,218	30	278,441	14	82.2	120,236	9	20,168	24	150,946	23	4.6
31	Oct.	93	19	30	42,770	12	1,026	10	211,182	29	82.6	108,491	9	19,844	22	150,324	23	4.5
31	Oct.	93	19	35	366,750	0	2,858	30	215,736	15	82.6	132,204	8	19,997	24	164,881	22	4.5
31	Oct.	93	19	40	145,830	0	45,435	11	13,661	28	82.6	143,487	7	19,643	22	147,108	22	4.3
31	Oct.	93	19	45	42,950	22	8,757	30	215,810	16	82.5	127,634	9	20,049	24	161,839	22	4.6
31	Oct.	93	19	50	15,594	12	5,716	11	39,191	25	82.4	126,263	10	20,290	22	146,393	22	4.5
31	Oct.	93	19	55	283,925	0	47,340	30	225,963	18	82.1	148,337	9	20,265	23	161,634	22	4.5
31	Oct.	93	20	0	4,820	20	5,936	11	41,206	23	82.2	118,894	10	20,369	22	146,660	22	4.5
31	Oct.	93	20	5	45,109	12	3,847	30	210,510	20	81.7	110,366	11	20,284	23	160,782	22	4.7
31	Oct.	93	20	10	357,865	0	3,041	11	39,489	20	81.9	133,265	9	16,082	22	145,833	21	4.4
31	Oct.	93	20	15	143,456	0	40,048	30	214,467	22	81.4	143,682	8	18,757	22	160,900	22	4.3
31	Oct.	93	20	20	39,047	22	4,653	11	35,309	18	81.6	124,211	10	18,656	20	145,080	21	4.3
31	Oct.	93	20	25	14,676	11	1,832	30	212,600	25	81.7	125,233	9	14,207	20	139,594	22	4.3
31	Oct.	93	20	30	277,181	0	54,521	11	29,486	15	81.3	144,767	8	18,665	20	124,452	20	4.1
31	Oct.	93	20	35	1,907	22	4,873	30	220,588	27	80.6	114,363	10	18,833	20	124,857	21	4.3
31	Oct.	93	20	40	45,594	12	5,863	11	31,203	12	81.2	106,010	11	15,536	20	126,319	20	4.3

Table 1: Measured Performance Data: Building 3490 Chillers

Measurement Time					Chiller 1		Chiller 2		Chiller 3			Running Hourly Average BTUH / kWH for Chillers						Total
Day	Month	Yr	Hr	Min	BTUH	KW	BTUH	KW	BTUH	KW	OS Air °F	# 1 BTUH	# 1 kW	# 2 BTUH	# 2 kW	# 3 BTUH	# 3 kW	kWH
31	Oct.	93	20	45	354,196	0	52,653	11	17,766	28	81.0	131,948	9	19,194	19	109,815	21	4.1
31	Oct.	93	20	50	146,819	0	6,705	29	276,201	13	81.2	142,883	8	19,276	20	129,566	20	4.0
31	Oct.	93	20	55	27,662	22	4,653	11	29,636	26	81.2	121,528	10	15,719	18	113,205	21	4.1
31	Oct.	93	21	0	17,572	0	50,564	29	196,402	15	81.1	122,590	8	19,438	20	126,138	20	4.0
31	Oct.	93	21	5	245,561	0	3,884	11	43,222	23	81.1	139,295	7	19,441	18	112,197	20	3.8
31	Oct.	93	21	10	4,317	22	5,863	29	200,433	17	81.0	109,832	9	19,676	20	125,609	20	4.1
31	Oct.	93	21	15	44,695	12	49,502	11	35,384	21	80.7	101,602	10	20,464	18	110,686	20	4.0
31	Oct.	93	21	20	363,801	0	5,716	29	202,373	20	79.6	128,665	8	20,552	20	124,608	20	4.0
31	Oct.	93	21	25	87,304	0	6,669	11	29,561	18	79.3	134,717	8	20,955	18	109,355	19	3.8
31	Oct.	93	21	30	30,576	22	54,375	29	192,744	22	79.6	114,167	9	20,943	20	122,959	20	4.1
31	Oct.	93	21	35	238,439	0	6,742	11	31,651	14	79.7	133,878	8	21,099	18	107,215	19	3.7
31	Oct.	93	21	40	167,071	0	4,873	29	204,464	20	79.0	144,001	7	21,017	20	121,653	20	3.8
31	Oct.	93	21	45	33,616	13	56,317	11	29,561	16	78.6	117,286	8	21,322	20	122,636	19	3.8
31	Oct.	93	21	50	20,936	12	5,899	29	203,120	23	78.3	106,796	9	21,255	20	116,546	19	4.0
31	Oct.	93	21	55	245,004	0	6,705	11	23,365	13	78.5	124,908	7	21,426	20	116,023	18	3.8
31	Oct.	93	22	0	189,086	0	61,923	11	23,514	25	79.3	139,200	7	22,372	18	101,616	19	3.7
31	Oct.	93	22	5	3,309	13	7,914	11	50,836	11	79.3	119,013	8	22,708	18	102,250	18	3.7
31	Oct.	93	22	10	20,468	0	2,015	11	25,530	25	78.8	120,359	6	22,388	17	87,675	19	3.5
31	Oct.	93	22	15	261,767	0	45,398	29	204,165	13	78.3	138,448	5	22,046	18	101,740	18	3.5
31	Oct.	93	22	20	190,992	0	1,832	11	29,262	23	77.8	124,047	5	21,722	17	87,314	19	3.4
31	Oct.	93	22	25	2,410	12	14,620	29	181,173	16	76.8	116,973	6	22,384	18	99,949	19	3.6
31	Oct.	93	22	30	19,029	0	77,349	11	29,188	19	77.3	116,011	4	24,299	17	86,319	18	3.3
31	Oct.	93	22	35	83,940	0	11,835	29	200,806	19	77.2	103,136	4	24,723	18	100,415	19	3.4
31	Oct.	93	22	40	318,332	0	5,899	11	29,113	16	76.9	115,741	4	24,809	17	85,803	18	3.3
31	Oct.	93	22	45	32,249	0	4,653	29	208,868	21	75.6	115,627	3	20,504	18	100,745	19	3.4
31	Oct.	93	22	50	9,604	21	-	11	21,723	12	76.3	114,683	4	20,012	17	85,629	18	3.2
31	Oct.	93	22	55	30,828	0	5,899	11	92,938	23	76.4	96,835	4	19,945	17	91,426	19	3.3
31	Oct.	93	23	0	259,447	0	4,837	11	21,723	11	76.2	102,698	4	15,188	17	91,277	17	3.2
31	Oct.	93	23	5	24,497	0	50,784	11	92,415	22	75.7	104,464	3	18,760	17	94,742	18	3.2
31	Oct.	93	23	10	62,357	20	6,925	11	17,244	11	76.4	107,954	5	19,169	17	94,052	17	3.2
31	Oct.	93	23	15	27,986	0	3,847	11	23,440	21	75.8	88,473	5	15,707	15	78,991	18	3.1
31	Oct.	93	23	20	197,665	0	50,418	11	17,617	11	74.5	89,029	5	19,755	15	78,021	17	3.1
31	Oct.	93	23	25	45,882	12	5,899	11	27,695	21	72.7	92,651	5	19,029	14	65,231	17	3.0
31	Oct.	93	23	30	12,356	11	8,721	11	17,617	11	73.8	92,095	5	13,310	14	64,267	17	3.0
31	Oct.	93	23	35	269,573	0	20,409	11	220,065	20	74.3	107,565	5	14,024	12	65,872	17	2.9
31	Oct.	93	23	40	59,551	0	1,832	11	25,455	11	74.3	86,000	5	13,685	12	65,567	16	2.8
31	Oct.	93	23	45	414	12	5,679	28	11,869	18	74.5	83,347	6	13,771	12	49,150	16	2.9

Table 1: Measured Performance Data: Building 3490 Chillers

Measurement Time					Chiller 1		Chiller 2		Chiller 3			Running Hourly Average BTUH / kWH for Chillers						Total
Day	Month	Yr	Hr	Min	BTUH	KW	BTUH	KW	BTUH	KW	OS Air °F	# 1 BTUH	# 1 kW	# 2 BTUH	# 2 kW	# 3 BTUH	# 3 kW	kWH
31	Oct.	93	23	50	50,504	0	5,863	11	35,458	12	74.7	86,755	5	14,259	12	50,295	16	2.8
31	Oct.	93	23	55	186,370	0	8,757	11	13,959	11	73.1	99,717	5	14,498	12	43,713	15	2.7
1	Nov.	93	0	0	22,572	0	5,863	11	7,763	19	72.6	79,977	5	14,583	12	42,550	16	2.7
1	Nov.	93	0	5	2,806	12	5,899	11	51,209	11	72.7	78,170	6	10,843	12	39,116	15	2.7
1	Nov.	93	0	10	42,339	0	61,190	11	13,959	11	73.0	76,502	4	15,365	12	38,842	15	2.6
1	Nov.	93	0	15	276,084	0	4,910	11	13,511	19	73.2	97,176	4	15,453	12	38,015	15	2.6
1	Nov.	93	0	20	35,684	0	13,374	11	47,551	11	72.7	83,678	4	12,366	12	40,510	15	2.6
1	Nov.	93	0	25	16,295	20	49,355	11	15,676	11	71.9	81,212	5	15,988	12	39,508	14	2.6
1	Nov.	93	0	30	37,680	0	-	3	5,748	17	71.6	83,323	4	15,261	12	38,519	14	2.5
1	Nov.	93	0	35	15,720	0	5,899	11	3,658	4	70.7	62,168	4	14,052	12	20,485	13	2.4
1	Nov.	93	0	40	124,426	0	5,863	11	192,594	11	68.5	67,575	4	14,388	12	34,413	13	2.4
1	Nov.	93	0	45	522	0	3,884	11	11,496	11	69.8	67,584	3	14,238	10	34,382	12	2.1
1	Nov.	93	0	50	73,149	12	5,899	28	6,196	18	69.2	69,471	4	14,241	12	31,944	13	2.4
1	Nov.	93	0	55	19,515	0	3,847	11	9,854	11	70.6	55,566	4	13,832	12	31,601	13	2.4
1	Nov.	93	1	0	265,868	0	49,465	11	212,003	11	68.5	75,841	4	17,465	12	48,621	12	2.3
1	Nov.	93	1	5	183,798	0	5,899	11	23,514	11	67.5	90,923	3	17,465	12	46,313	12	2.2
1	Nov.	93	1	10	14,335	12	5,899	29	6,196	14	67.8	88,590	4	12,858	13	45,667	12	2.4
1	Nov.	93	1	15	2,896	0	11,542	3	9,854	9	69.1	65,824	4	13,411	13	45,362	11	2.3
1	Nov.	93	1	20	24,641	0	-	11	5,748	8	68.4	64,904	4	12,296	13	41,878	11	2.3
1	Nov.	93	1	25	299,627	0	5,863	11	110,779	11	70.0	88,515	2	8,672	13	49,803	11	2.2
1	Nov.	93	1	30	40,396	0	6,669	11	11,496	11	70.4	88,741	2	9,227	13	50,282	11	2.2
1	Nov.	93	1	35	31,943	11	48,622	11	6,196	18	69.8	90,093	3	12,788	13	50,494	12	2.3
1	Nov.	93	1	40	7,554	0	6,705	11	5,748	11	68.8	80,354	3	12,858	13	34,923	12	2.3
1	Nov.	93	1	45	242,666	0	7,731	11	3,732	11	70.4	100,532	3	13,178	13	34,276	12	2.3
1	Nov.	93	1	50	95,577	0	66,027	11	2,016	11	70.7	102,401	2	18,189	12	33,928	11	2.1
1	Nov.	93	1	55	11,889	17	5,679	11	243,281	11	69.3	101,766	3	18,342	12	53,380	11	2.2
1	Nov.	93	2	0	7,680	0	6,888	11	11,571	11	70.1	80,250	3	14,794	12	36,678	11	2.2
1	Nov.	93	2	5	247,612	0	6,852	28	5,748	15	71.4	85,568	3	14,873	13	35,197	12	2.4
1	Nov.	93	2	10	26,439	0	11,835	11	5,748	14	71.7	86,577	2	15,368	12	35,160	12	2.1
1	Nov.	93	2	15	5,720	12	6,705	11	7,838	11	71.5	86,812	3	14,965	12	34,992	12	2.3
1	Nov.	93	2	20	25,756	0	5,679	11	9,854	11	71.7	86,905	3	15,438	12	35,334	12	2.3
1	Nov.	93	2	25	15,234	0	46,680	11	2,016	11	72.1	63,205	3	18,839	12	26,270	12	2.3
1	Nov.	93	2	30	197,197	0	5,899	11	5,823	11	71.8	76,272	3	18,775	12	25,797	12	2.3
1	Nov.	93	2	35	61,961	12	6,705	11	13,586	11	72.2	78,774	3	15,282	12	26,413	11	2.3
1	Nov.	93	2	40	22,878	12	5,863	11	-	18	72.5	80,051	4	15,212	12	25,934	12	2.4
1	Nov.	93	2	45	14,263	0	7,731	11	6,196	11	72.3	61,017	4	15,212	12	26,140	12	2.4
1	Nov.	93	2	50	235,453	0	5,899	11	-	11	72.8	72,674	4	10,201	12	25,972	12	2.4

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Measurement Time					Chiller 1		Chiller 2		Chiller 3			Running Hourly Average BTUH / kWH for Chillers						Total
Day	Month	Yr	Hr	Min	BTUH	KW	BTUH	KW	BTUH	KW	OS Air °F	# 1 BTUH	# 1 kW	# 2 BTUH	# 2 kW	# 3 BTUH	# 3 kW	kWH
1	Nov.	93	2	55	203,025	0	5,863	11	7,838	11	72.7	88,602	3	10,217	12	6,351	12	2.3
1	Nov.	93	3	0	27,267	12	56,500	11	5,748	11	72.6	90,234	4	14,351	12	5,866	12	2.4
1	Nov.	93	3	5	1,403	12	6,742	11	137,951	11	72.5	69,716	5	14,342	11	16,883	12	2.3
1	Nov.	93	3	10	18,651	0	15,609	11	15,676	11	72.6	69,067	5	14,656	11	17,710	11	2.3
1	Nov.	93	3	15	242,486	0	67,859	29	4,180	16	70.9	88,798	4	19,752	12	17,406	12	2.4
1	Nov.	93	3	20	179,535	0	5,899	11	4,106	13	71.1	101,613	4	19,771	12	16,927	12	2.4
1	Nov.	93	3	25	4,317	12	6,705	11	-	11	71.3	100,703	5	16,439	12	16,759	12	2.5
1	Nov.	93	3	30	1,907	0	7,695	11	2,090	11	71.2	84,429	5	16,589	12	16,448	12	2.5
1	Nov.	93	3	35	13,274	0	57,526	11	1,642	11	70.8	80,371	4	20,824	12	15,452	12	2.4
1	Nov.	93	3	40	21,403	0	5,936	11	-	11	71.2	80,249	3	20,830	12	15,452	11	2.2
1	Nov.	93	3	45	201,676	0	6,925	11	11,944	11	69.9	95,866	3	20,763	12	15,931	11	2.2
1	Nov.	93	3	50	7,770	12	5,863	11	9,928	11	69.9	76,893	4	20,760	12	16,759	11	2.3
1	Nov.	93	3	55	24,479	12	5,716	28	6,196	13	70.3	62,014	5	20,748	14	16,622	12	2.6
1	Nov.	93	4	0	7,608	0	5,899	11	5,748	16	70.5	60,376	4	16,531	14	16,622	12	2.5
1	Nov.	93	4	5	18,543	0	6,888	11	-	11	70.8	61,804	3	16,543	14	5,126	12	2.4
1	Nov.	93	4	10	222,737	0	44,628	11	5,748	11	70.9	78,811	3	18,962	14	4,299	12	2.4
1	Nov.	93	4	15	169,715	0	5,899	11	4,106	11	70.4	72,747	3	13,798	12	4,292	12	2.3
1	Nov.	93	4	20	11,457	12	7,914	11	7,763	11	70.4	58,740	4	13,966	12	4,597	11	2.3
1	Nov.	93	4	25	18,741	12	6,669	11	7,838	11	70.5	59,943	4	13,963	12	5,250	11	2.3
1	Nov.	93	4	30	10,486	0	11,615	11	198,865	11	70.3	60,657	4	14,290	12	21,648	11	2.3
1	Nov.	93	4	35	9,946	0	6,888	11	14,034	11	70.5	60,380	4	10,070	12	22,681	11	2.3
1	Nov.	93	4	40	141,351	0	6,705	29	5,748	17	70.3	70,376	4	10,134	14	23,160	12	2.5
1	Nov.	93	4	45	9,155	0	45,544	11	6,196	11	69.7	54,332	4	13,353	14	22,681	12	2.5
1	Nov.	93	4	50	9,533	12	3,884	11	3,658	11	69.6	54,479	4	13,188	14	22,158	12	2.5
1	Nov.	93	4	55	9,604	0	5,679	11	2,016	11	69.8	53,240	3	13,185	12	21,810	12	2.3
1	Nov.	93	5	0	23,849	0	5,679	11	3,658	11	69.6	54,593	3	13,166	12	21,636	11	2.2
1	Nov.	93	5	5	218,043	0	4,910	11	2,090	11	69.6	71,218	3	13,001	12	21,810	11	2.2
1	Nov.	93	5	10	181,766	0	4,873	11	11,944	11	69.5	67,804	3	9,688	12	22,326	11	2.2
1	Nov.	93	5	15	18,687	12	4,873	11	7,838	11	69.6	55,218	4	9,603	12	22,637	11	2.3
1	Nov.	93	5	20	12,410	12	36,824	11	4,106	18	69.6	55,298	4	12,012	12	22,332	12	2.4
1	Nov.	93	5	25	10,971	0	3,884	11	2,090	11	68.7	54,650	3	11,780	12	21,853	12	2.3
1	Nov.	93	5	30	6,187	0	6,888	11	-	11	69.1	54,292	3	11,386	12	5,281	12	2.3
1	Nov.	93	5	35	149,571	0	7,695	11	7,838	11	68.8	65,927	3	11,453	12	4,765	12	2.3
1	Nov.	93	5	40	21,169	0	-	11	2,090	11	67.1	55,912	3	10,895	11	4,460	11	2.1
1	Nov.	93	5	45	15,756	12	4,873	11	1,642	11	68.5	56,462	4	7,505	11	4,081	11	2.2
1	Nov.	93	5	50	15,702	0	5,679	11	78,979	11	68.0	56,976	3	7,655	11	10,358	11	2.1
1	Nov.	93	5	55	14,748	0	41,587	11	5,823	11	67.9	57,405	3	10,647	11	10,675	11	2.1

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Day	Month	Yr	Hr	Min	BTUH	KW	BTUH	KW	BTUH	KW	OS Air °F	# 1 BTUH	# 1 kW	# 2 BTUH	# 2 kW	# 3 BTUH	# 3 kW	kWH
1	Nov.	93	6	0	216,964	0	3,884	11	-	17	67.9	73,498	3	10,498	11	10,370	12	2.2
1	Nov.	93	6	5	116,926	0	5,899	11	2,016	11	67.7	65,071	3	10,580	11	10,364	12	2.2
1	Nov.	93	6	10	26,295	12	5,863	11	4,106	11	67.1	52,116	4	10,662	11	9,711	12	2.2
1	Nov.	93	6	15	7,608	0	56,500	11	3,658	11	67.5	51,192	3	14,965	11	9,362	12	2.2
1	Nov.	93	6	20	7,698	0	3,041	11	1,642	11	67.0	50,800	2	12,149	11	9,157	11	2.0
1	Nov.	93	6	25	8,561	0	5,679	11	2,090	11	67.5	50,599	2	12,299	11	9,157	11	2.0
1	Nov.	93	6	30	157,700	0	44,665	11	2,090	11	65.9	63,225	2	15,447	11	9,331	11	2.0
1	Nov.	93	6	35	32,752	0	4,910	11	1,642	11	67.6	53,490	2	15,215	11	8,815	11	2.0
1	Nov.	93	6	40	24,461	12	4,873	11	41,356	11	66.8	53,764	3	15,621	11	12,087	11	2.1
1	Nov.	93	6	45	14,281	0	3,041	11	7,838	11	66.7	53,641	2	15,469	11	12,603	11	2.0
1	Nov.	93	6	50	10,953	0	-	11	3,732	18	67.8	53,246	2	14,995	11	6,333	12	2.1
1	Nov.	93	6	55	216,011	0	3,847	11	-	11	67.3	70,018	2	11,850	11	5,848	12	2.1
1	Nov.	93	7	0	8,148	0	5,899	11	3,658	11	67.1	52,616	2	12,018	11	6,152	11	2.0
1	Nov.	93	7	5	6,727	12	47,743	11	4,106	11	67.6	43,433	3	15,505	11	6,327	11	2.1
1	Nov.	93	7	10	6,205	0	2,858	11	4,106	11	67.3	41,759	2	15,255	11	6,327	11	2.0
1	Nov.	93	7	15	10,486	0	3,041	11	4,106	11	67.6	41,999	2	10,800	11	6,364	11	2.0
1	Nov.	93	7	20	116,351	0	2,821	11	15,676	11	68.0	51,053	2	10,782	11	7,533	11	2.0
1	Nov.	93	7	25	163,258	0	-	27	7,763	12	67.3	63,944	2	10,308	12	8,006	11	2.2
1	Nov.	93	7	30	49,012	13	3,041	11	1,642	17	68.3	54,887	3	6,840	12	7,969	12	2.3
1	Nov.	93	7	35	23,939	12	5,716	11	7,838	11	68.5	54,153	4	6,907	12	8,485	12	2.4
1	Nov.	93	7	40	10,971	0	32,207	11	-	11	68.8	53,028	3	9,185	12	5,039	12	2.3
1	Nov.	93	7	45	8,561	0	2,858	11	2,090	11	68.7	52,552	3	9,169	12	4,560	12	2.3
1	Nov.	93	7	50	182,629	0	2,858	11	1,642	11	68.0	66,858	3	9,408	12	4,386	11	2.2
1	Nov.	93	7	55	18,723	0	2,821	11	2,090	11	68.8	50,417	3	9,322	12	4,560	11	2.2
1	Nov.	93	8	0	4,317	12	44,738	11	-	11	68.8	50,098	4	12,559	12	4,255	11	2.3
1	Nov.	93	8	5	10,108	0	2,015	11	3,732	11	68.3	50,380	3	8,748	12	4,224	11	2.2
1	Nov.	93	8	10	11,475	0	3,847	11	9,928	11	68.2	50,819	3	8,830	12	4,709	11	2.2
1	Nov.	93	8	15	193,546	0	5,679	11	6,121	18	68.0	66,074	3	9,050	12	4,877	12	2.3
1	Nov.	93	8	20	174,463	0	1,026	11	4,106	11	67.2	70,917	3	8,901	12	3,913	12	2.3
1	Nov.	93	8	25	37,483	12	-	11	5,823	11	67.5	60,436	4	8,901	11	3,751	12	2.2
1	Nov.	93	8	30	15,720	12	4,873	11	4,106	11	67.9	57,661	4	9,053	11	3,956	11	2.2
1	Nov.	93	8	35	8,076	0	52,616	11	4,106	11	68.5	56,339	3	12,962	11	3,645	11	2.1
1	Nov.	93	8	40	7,572	0	1,026	11	-	11	68.3	56,056	3	10,363	11	3,645	11	2.1
1	Nov.	93	8	45	140,308	0	1,026	11	7,838	11	68.2	67,035	3	10,211	11	4,124	11	2.1
1	Nov.	93	8	50	22,069	0	-	11	5,748	18	68.4	53,655	3	9,972	11	4,466	12	2.2
1	Nov.	93	8	55	11,961	12	-	11	7,838	11	68.7	53,091	4	9,737	11	4,945	12	2.2
1	Nov.	93	9	0	16,709	0	-	11	5,748	11	69.0	54,124	3	6,009	11	5,424	12	2.2

Table 1: Measured Performance Data: Building 3490 Chillers

Measurement Time					Chiller 1		Chiller 2		Chiller 3			Running Hourly Average BTUH / kWH for Chillers						Total
Day	Month	Yr	Hr	Min	BTUH	KW	BTUH	KW	BTUH	KW	OS Air °F	# 1 BTUH	# 1 kW	# 2 BTUH	# 2 kW	# 3 BTUH	# 3 kW	kWH
1	Nov.	93	9	5	18,561	0	-	11	2,090	11	68.9	54,829	3	5,841	11	5,288	12	2.2
1	Nov.	93	9	10	209,931	0	41,807	11	1,642	11	69.0	71,367	3	9,004	11	4,597	12	2.2
1	Nov.	93	9	15	179,841	0	3,884	11	7,913	11	68.5	70,224	3	8,855	11	4,746	11	2.1
1	Nov.	93	9	20	56,566	13	8,757	11	11,571	11	69.4	60,400	4	9,499	11	5,369	11	2.2
1	Nov.	93	9	25	12,428	0	8,721	11	6,196	18	69.5	58,312	3	10,226	11	5,400	12	2.2
1	Nov.	93	9	30	7,086	0	22,534	11	4,106	11	69.6	57,592	2	11,698	11	5,400	12	2.1
1	Nov.	93	9	35	5,180	0	3,884	11	5,748	11	69.7	57,351	2	7,637	11	5,536	12	2.1
1	Nov.	93	9	40	151,333	0	9,783	11	5,748	11	69.8	69,331	2	8,366	11	6,015	12	2.1
1	Nov.	93	9	45	13,004	0	30,082	11	3,658	11	70.0	58,722	2	10,788	11	5,667	12	2.1
1	Nov.	93	9	50	11,547	13	7,768	11	5,748	11	70.7	57,846	3	11,435	11	5,667	11	2.1
1	Nov.	93	9	55	16,205	0	4,910	11	4,106	11	70.7	58,199	2	11,844	11	5,356	11	2.0
1	Nov.	93	10	0	12,860	0	7,695	11	11,571	11	71.6	57,879	2	12,485	11	5,841	11	2.0
1	Nov.	93	10	5	205,561	0	48,732	11	6,196	18	71.3	73,462	2	16,546	11	6,183	12	2.1
1	Nov.	93	10	10	73,670	0	4,910	11	7,763	11	71.5	62,107	2	13,472	11	6,694	12	2.1
1	Nov.	93	10	15	13,849	13	4,910	11	6,121	11	72.3	48,274	3	13,557	11	6,544	12	2.2
1	Nov.	93	10	20	5,702	0	33,123	11	2,090	11	72.8	44,035	2	15,588	11	5,754	12	2.1
1	Nov.	93	10	25	9,083	0	8,794	11	140,116	11	72.8	43,757	2	15,594	11	16,914	11	2.0
1	Nov.	93	10	30	146,693	0	14,656	11	14,109	11	72.3	55,391	2	14,937	11	17,748	11	2.0
1	Nov.	93	10	35	159,895	0	5,863	30	7,838	17	71.7	68,283	2	15,102	12	17,922	12	2.2
1	Nov.	93	10	40	28,939	13	3,884	11	5,748	12	73.2	58,084	3	14,611	12	17,922	12	2.3
1	Nov.	93	10	45	27,806	13	11,615	11	5,748	11	73.2	59,317	4	13,072	12	18,096	12	2.4
1	Nov.	93	10	50	15,702	0	15,426	11	-	11	73.8	59,664	3	13,710	12	17,617	12	2.3
1	Nov.	93	10	55	10,953	0	53,422	11	5,748	11	74.0	59,226	3	17,752	12	17,754	12	2.3
1	Nov.	93	11	0	148,456	0	12,678	11	2,090	11	74.0	70,526	3	18,168	12	16,964	12	2.3
1	Nov.	93	11	5	8,148	0	16,488	11	164,153	11	73.8	54,075	3	15,481	12	30,127	11	2.2
1	Nov.	93	11	10	504	13	9,746	11	9,928	11	74.4	47,977	4	15,884	12	30,307	11	2.3
1	Nov.	93	11	15	7,716	0	7,768	11	5,748	18	74.9	47,466	3	16,122	12	30,276	12	2.3
1	Nov.	93	11	20	20,972	0	4,910	11	3,658	11	74.8	48,739	3	13,771	12	30,407	12	2.3
1	Nov.	93	11	25	192,791	0	11,578	11	4,180	11	75.2	64,048	3	14,003	12	19,079	12	2.3
1	Nov.	93	11	30	169,175	0	51,700	11	4,106	11	75.1	65,921	3	17,090	12	18,245	12	2.3
1	Nov.	93	11	35	51,925	13	10,809	11	4,106	11	75.5	56,924	4	17,502	11	17,934	11	2.2
1	Nov.	93	11	40	25,882	13	806	11	16,199	11	76.1	56,669	4	17,246	11	18,805	11	2.2
1	Nov.	93	11	45	13,795	0	34,992	11	12,018	11	75.5	55,501	3	19,194	11	19,328	11	2.1
1	Nov.	93	11	50	7,176	0	7,768	11	9,854	18	75.5	54,791	3	18,555	11	20,149	12	2.2
1	Nov.	93	11	55	138,132	0	8,757	11	9,928	11	76.1	65,389	3	14,833	11	20,497	12	2.2
1	Nov.	93	12	0	9,568	0	3,847	11	5,748	11	76.5	53,815	3	14,098	11	20,802	12	2.2
1	Nov.	93	12	5	504	13	5,936	11	5,748	11	76.2	53,178	4	13,218	11	7,602	12	2.2

Table 1: Measured Performance Data: Building 3490 Chillers

Measurement Time					Chiller 1		Chiller 2		Chiller 3			Running Hourly Average BTUH / kWH for Chillers						Total
Day	Month	Yr	Hr	Min	BTUH	KW	BTUH	KW	BTUH	KW	OS Air °F	# 1 BTUH	# 1 kW	# 2 BTUH	# 2 kW	# 3 BTUH	# 3 kW	kWH
1	Nov.	93	12	10	10,126	0	11,652	11	5,823	11	76.8	53,980	3	13,377	11	7,260	12	2.2
1	Nov.	93	12	15	12,860	0	9,746	11	146,611	11	76.8	54,409	3	13,542	11	18,998	11	2.1
1	Nov.	93	12	20	172,233	0	40,928	11	9,928	11	77.1	67,014	3	16,543	11	19,521	11	2.1
1	Nov.	93	12	25	146,135	0	7,768	10	6,196	19	77.3	63,126	3	16,226	11	19,689	12	2.2
1	Nov.	93	12	30	32,662	13	12,604	11	9,480	11	77.3	51,750	4	12,968	11	20,137	12	2.2
1	Nov.	93	12	35	11,403	13	10,553	11	6,196	11	77.4	48,373	4	12,946	11	20,311	12	2.2
1	Nov.	93	12	40	9,982	0	19,456	11	7,763	11	77.5	47,048	3	14,501	11	19,608	12	2.2
1	Nov.	93	12	45	191,334	0	10,809	11	173,708	11	77.7	61,843	3	12,485	11	33,082	12	2.2
1	Nov.	93	12	50	158,528	0	8,757	11	15,676	11	78.1	74,456	3	12,568	11	33,567	11	2.1
1	Nov.	93	12	55	41,799	13	43,932	30	17,766	18	78.4	66,428	4	15,499	12	34,220	12	2.4
1	Nov.	93	13	0	21,547	13	11,615	11	173,260	11	78.4	67,426	6	16,146	12	48,180	12	2.5
1	Nov.	93	13	5	12,392	0	4,873	11	25,530	11	78.6	68,417	4	16,058	12	49,828	12	2.4
1	Nov.	93	13	10	55,289	0	57,379	30	114,138	17	78.9	72,180	4	19,868	14	58,855	13	2.6
1	Nov.	93	13	15	147,664	0	6,779	3	21,872	11	78.8	83,414	4	19,621	13	48,460	13	2.5
1	Nov.	93	13	20	1,007	13	7,768	30	202,224	13	79.7	69,145	6	16,858	15	64,484	13	2.8
Totals																		860

Table 2: Bin Temperature Data from TM 5-785

Bin Temp. Data		Monthly Hours of Occurance @ TM 5-785													Total
High °F	Low °F	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total	Deg-Hrs
124	120	0	0	0	0	0	0	0	0	0	0	0	0	0	-
119	115	0	1	2	0	0	0	0	0	0	0	0	0	3	156
114	110	1	15	21	9	4	0	0	0	0	0	0	0	50	2,350
109	105	5	43	80	64	37	0	0	0	0	0	0	0	229	9,618
104	100	21	67	112	108	70	16	0	0	0	0	0	4	398	14,726
99	95	57	90	109	108	88	43	0	0	0	0	0	17	512	16,384
94	90	81	93	126	132	99	63	2	0	0	0	5	40	641	17,307
89	85	86	106	164	168	125	79	18	0	0	6	27	66	845	18,590
84	80	96	109	96	111	129	95	38	4	3	19	52	77	829	14,093
79	75	107	97	26	33	87	116	62	23	16	38	67	89	761	9,132
74	70	108	62	5	10	53	118	83	53	43	61	84	104	784	5,488
69	65	93	27	0	1	22	108	105	79	73	91	101	115	815	1,630
64	60	54	8	-	-	3	68	130	108	98	107	124	102	802	-
59	55	27	2	-	-	0	26	124	144	137	121	129	67	777	-
54	50	6	-	-	-	-	9	94	150	145	108	97	29	638	-
49	45	1	-	-	-	-	1	45	120	121	75	42	7	412	-
44	40	-	-	-	-	-	-	16	50	72	31	12	1	182	-
39	35	-	-	-	-	-	-	3	12	29	9	2	-	55	-
34	30	-	-	-	-	-	-	0	1	7	2	0	-	10	-
Totals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**109,474**

CONSTRUCTION COST ESTIMATE

CONSTRUCTION COST ESTIMATE	Date Prepared: January 1994	Sheet: 1	of: 1
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: **Code A (no design competed)**	
Location: Yuma Proving Ground, Arizona Bldg 3490			
Engineer-Architect: Keller & Gannon			
Drawing No.: Manifold Chillers	Estimator: R. Bush	Checked By: B. Horst	

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
2" Steel Pipe	600	Ft	$9.35	$5,610	$5.73	$3,438	$9,048
6" Steel Pipe	300	Ft	$25.71	$7,713	$25.62	$7,686	$15,399
Pipe Fittings	1	Job	$800	$800	$800	$800	$1,600
Relocate Chiller #1	1	Ea	$4,000	$4,000		$0	$4,000
Demolish & Relocate Pipe	1	Job	$3,000	$3,000		$0	$3,000
5 Ton Chilled Water Fan-Coil Unit	1	Ea	$150	$150	$ 1,500	$1,500	$1,650
Subtotal				$21,273		$13,424	$34,697
State Sales Tax	5.5%	%		-		$738	$738
Subtotal							$35,435
Contractor OH & Profit	30.0%	%					$10,631
Subtotal							$46,066
Bond	1.0%	%					$461
Subtotal							$46,527
Estimating Contingency	10.0%	%					$4,653
Total Probable Construction Cost							$51,179

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)
Manifold Building 3490 Chillers

Location: Yuma Proving Ground, Arizona Region No. 4 Project No.
Project Title: Manifold Building 3490 Chillers Fiscal Year FY96
Discrete Portion Name: Building 3490 Preparer: KELLER & GANNON
Analysis Date: January 1994 Economic Life: 15 Years

1. Investment Costs

A. Construction Costs	$51,179		
B. SIOH	$ 3,071		
C. Design Cost	$ 3,071		
D. Total Cost (1A+1B+1C)	$ 57,321		
E. Salvage Value of Existing Equipment		$0	
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$57,321

2. Energy Savings (+)/Cost(-):
Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost $/KWH	Saving KWH/Yr(2)	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	92,825	$7,704	11.30	$87,060
B. Dist	$0.00	0.00	$0.00	12.18	$0
C. LPG	$0.00	0.00	$0.00	13.25	$0
D. Other					
E. Demand Savings					
F. Total		92,825	$7,704		$87,060

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($1,320)		
(1) Discount Factor (Table A)		10.74	
(2) Discounted Savings/Cost (3A x 3A1)			($14,177)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($14,177)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)): 8.98 Years
5. Total Net Discounted Savings (2F5+3C): $72,884
6. Savings to Investment Ratio (SIR) 5/1G: 1.27
7. Adjusted Internal Rate of Return (AIRR): 6.19%

Appendix G

Lighting Data and Energy Calculations

Appendix G

Table of Contents

LIGHTING ENERGY CALCULATION METHODOLOGY

Lighting Energy Use

Lighting energy use for buildings investigated in conjunction with the Chiller/Boiler Study is determined based on a combination of field observations, design data and on experience in similar projects.

Electric power usage for present and proposed fixture retrofits is determined similarly. Fixture electric loads (kW) are determined and then multiplied by the operating hours per year.

Operating hours per year are determined based on the building schedule and on the function of the room in which the fixture is located. Room and building schedule are determined by interviewing occupants. A demand/diversity factor is applied to scheduled room usage.

Existing fixture and retrofit fixture energy use calculations are explained in detail below; tabular summaries of calculations to determine present lighting energy use appear as Tables G-1 through G-10.

Lighting Energy Calculations

Label	Contents / Calculation Explanation	
L_TYPE	Lamp types: Incandescent, Fluorescent, FS fluorescent-surface mount	(Catalog Data)
L/FXTR	Lamps per fixture	(Field Data)
W/LAMP	Watts per lamp	(Field Data)
#FXTR	Number of fixtures in room/area	(Field Data)
BAL_W	Ballast load (watts)	(Field Data)
HR/WK	Operating hours per week	(Field Data)
DEMAND	Demand factor	(See table)
KW	((L/FXTR * W/LAMP) + BAL_W) * #FXTR/1000 = Lighting load (kW)	
KWH/Y	((L/FXTR * W/LAMP) + BAL_W) * #FXTR * HR/WK * 52 * DEMAND/1000 = = Annual power use (kWh/year)	

Room/Task Lighting Demand Factors

Task Code	Description	Factor
1	Corridor	1.0
2	Kitchens	0.8
3	Dining	0.8
4	Offices - general	1.0
5	Offices - ledgers	1.0
6	Offices - drafting	1.0
7	Laundry	1.0
8	Toilet/Bathing/Lockers	0.8 - 0.9
9	Sleeping quarters	0.8
10	Supply rooms	0.8
11	Repair shops	0.8
12	Storage rooms	0.8
13	Retail stores	NA
14	Janitor closet	0.8
15	Mechanical room	0.8
16	Conference room	1.0
17	Lounge	0.8
18	TV room	0.8

Note: Any changes to this schedule needed for specific building calculations are shown as legends on Lighting Energy Use tabulations.

TABLE G-1 BUILDING 451 PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kHW/Yr)
451	NCO Open Mess	1	1	R	F	4	40	1	40	50	140	1.0	0.2	1,456
451	NCO Open Mess	1	1	R	I	1	100	4	0	50	140	1.0	0.4	2,912
451	NCO Open Mess	2	16	R	I	1	100	10	0	40	70	0.8	1.0	2,912
451	NCO Open Mess	3	1	R	I	1	100	1	0	20	140	1.0	0.1	728
451	NCO Open Mess	4	8	R	F	4	40	2	40	80	70	0.9	0.4	1,310
451	NCO Open Mess	4	8	S	I	1	100	12	0	80	70	0.9	1.2	3,931
451	NCO Open Mess	5	8	S	F	2	40	1	20	60	70	0.9	0.1	328
451	NCO Open Mess	5	8	R	F	4	40	2	40	60	70	0.9	0.4	1,310
451	NCO Open Mess	6	14	R	I	1	100	1	0	20	46	0.5	0.1	120
451	NCO Open Mess	7	1	R	I	1	100	1	0	20	140	1.0	0.1	728
451	NCO Open Mess	8	4	R	F	4	40	3	40	60	105	1.0	0.6	3,276
451	NCO Open Mess	9	17	R	F	2	40	2	20	20	70	0.8	0.2	546
451	NCO Open Mess	9	17	R	I	1	75	15	0	20	70	0.8	1.1	3,071
451	NCO Open Mess	10A	12	S	F	4	40	1	40	40	46	1.0	0.2	480
451	NCO Open Mess	10B	12	S	F	4	40	1	40	40	46	1.0	0.2	480
451	NCO Open Mess	11	12	R	F	4	40	1	40	40	46	1.0	0.2	480
451	NCO Open Mess	12	18	R	I	1	75	3	0	50	70	0.8	0.2	614
451	NCO Open Mess	13	3	R	I	1	60	8	0	40	70	0.8	0.5	1,310
451	NCO Open Mess	13	3	R	I	1	60	3	0	40	70	0.8	0.2	491
451	NCO Open Mess	13	3	P	I	3	60	8	0	60	70	0.8	1.4	3,931
451	NCO Open Mess	14	3	S	I	1	150	7	0	60	70	0.8	1.1	2,867
451	NCO Open Mess	14	3	P	I	3	60	3	0	80	70	0.8	0.5	1,474
451	NCO Open Mess	14	3	S	I	1	150	8	0	80	70	0.8	1.2	3,276
451	NCO Open Mess	15	12	R	F	2	40	4	20	20	46	1.0	0.4	961
451	NCO Open Mess	16	12	R	F	2	40	2	20	20	46	1.0	0.2	480
451	NCO Open Mess	17	8	R	F	2	40	7	20	20	70	1.0	0.7	2,548
451	NCO Open Mess	18	8	R	F	2	40	8	20	50	70	1.0	0.8	2,912
451	NCO Open Mess	18	8	R	F	2	40	6	20	50	70	1.0	0.6	2,184
451	NCO Open Mess	19	1	R	F	2	40	10	20	45	140	1.0	1.0	7,280
451	NCO Open Mess	20	12	R	F	2	40	10	20	50	46	1.0	1.0	2,402

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TABLE G-1 BUILDING 451 PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kHW/Yr)
451	NCO Open Mess	21	2	R	F	2	40	10	20	50	105	0.8	1.0	4,095
451	NCO Open Mess	22	2	R	F	2	40	3	20	60	105	0.8	0.3	1,229
451	NCO Open Mess	23	12	R	F	2	40	5	20	50	46	1.0	0.5	1,201
451	NCO Open Mess	24	15	S	F	1	40	2	20	20	46	0.5	0.1	144

TOTAL BLDG (kWH/Yr)	TOTAL LOAD (kW)	CONN (W/SF)	BLDG SQ FEET
63,489	18.3	2.8	6,534

LTG LEGEND

	Task Code		Fixt Type
1	Corridor	R-	Recessed
2	Kitchens	S-	Surface
3	Dining	P-	Pendant
4	Offices - general	O-	Others
5	Offices - ledgers		
6	Offices - drafting		Lamp Type
7	Laundry	I-	Incandescent
8	Toilets	F-	Fluorescent
9	Sleeping quarters		
10	Supply rooms		
11	Repair shops		
12	Storage room		
13	Retail store		
14	Janitor closet		
15	Mechanical room		
16	Conference		
17	Lounge		

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TABLE G-2 BUILDING 506A PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506A	E M Barracks	108A	8	S	F	2	40	1	20	10	84	0.8	0.1	328
506A	E M Barracks	108C	14	S	I	1	60	2	0	10	84	0.8	0.1	393
506A	E M Barracks	207A	8	S	F	2	40	1	20	10	84	0.8	0.1	328
506A	E M Barracks	207C	14	S	I	1	60	2	0	10	84	0.8	0.1	393
506A	E M Barracks	212A	8	S	F	2	40	1	20	10	84	0.8	0.1	328
506A	E M Barracks	212C	14	S	I	2	60	2	0	10	84	0.8	0.2	786
506A	E M Barracks	307A	8	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	307B	8	S	F	1	40	8	10	20	84	0.8	0.4	1,310
506A	E M Barracks	307C	14	S	I	1	60	2	0	10	84	0.8	0.1	393
506A	E M Barracks	312A	8	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	312B	8	S	F	1	40	8	10	20	84	0.8	0.4	1,310
506A	E M Barracks	312C	14	S	I	1	60	2	0	10	84	0.8	0.1	393
506A	E M Barracks	B1	12	LOCK	LOCK	LOCKED	LOCKED	LOCKED	LOCKED	LOCKED	LOCKED	LOCKED	LOCKED	LOCKED
506A	E M Barracks	B2	1	S	F	2	40	3	20	20	40	1.0	0.3	629
506A	E M Barracks	B3	12	S	F	2	40	18	20	20	40	0.8	1.8	3,019
506A	E M Barracks	100	16	R	F	2	40	8	20	50	60	1.0	0.8	2,516
506A	E M Barracks	100	16	R	I	1	100	4		50	60	1.0	0.4	1,258
506A	E M Barracks	101	4	R	F	2	40	5	20	50	60	1.0	0.5	1,572
506A	E M Barracks	102	4	S	F	2	40	1	20	20	60	1.0	0.1	314
506A	E M Barracks	103	4	S	F	2	40	1	20	20	60	1.0	0.1	314
506A	E M Barracks	104	4	S	F	2	40	2	20	20	60	1.0	0.2	629
506A	E M Barracks	105	15	S	I	1	60	1	0	10	17	0.8	0.1	42
506A	E M Barracks	106	7	S	F	2	40	2	20	20	55	1.0	0.2	576
506A	E M Barracks	107	4	S	F	2	40	1	20	20	60	1.0	0.1	312
506A	E M Barracks	109	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	110	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	111	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	112	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	113	9	S	F	2	50	1	20	20	84	0.8	0.1	393
506A	E M Barracks	114	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	115	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	116	9	S	F	2	40	1	20	20	84	0.8	0.1	328

TABLE G-2 BUILDING 506A PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506A	E M Barracks	117	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	118	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	119	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	120	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	121	4	S	F	2	40	2	20	20	60	1.0	0.2	629
506A	E M Barracks	122	4	S	F	2	40	6	20	60	60	1.0	0.6	1,887
506A	E M Barracks	123	4	S	F	2	40	4	20	60	60	1.0	0.4	1,258
506A	E M Barracks	124	4	S	F	2	40	6	20	60	60	1.0	0.6	1,887
506A	E M Barracks	125	1	S	F	1	40	2	10	10	168	1.0	0.1	874
506A	E M Barracks	126	1	S	F	1	40	2	10	10	168	1.0	0.1	874
506A	E M Barracks	127	1	S	F	1	40	14	10	10	168	1.0	0.7	6,115
506A	E M Barracks	128	17	R	I	1	100	21	0	50	84	0.8	2.1	7,338
506A	E M Barracks	128	17	S	I	1	40	7	0	30	84	0.8	0.3	978
506A	E M Barracks	128	17	R	F	4	40	1	40	50	84	0.8	0.2	699
506A	E M Barracks	129	18	R	F	2	40	2	20	50	84	0.8	0.2	699
506A	E M Barracks	129	18	R	I	1	100	18	0	50	84	0.8	1.8	6,290
506A	E M Barracks	201	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	202	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	203	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	204	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	205	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	206	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	208	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	209	15	S	I	1	75	1	0	10	17	0.8	0.1	52
506A	E M Barracks	210	9	S	F	2	40	2	20	20	84	0.8	0.2	655
506A	E M Barracks	211	9	S	F	2	40	2	20	20	84	0.8	0.2	655
506A	E M Barracks	213	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	214	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	215	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	216	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	217	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	218	9	S	F	2	40	1	20	20	84	0.8	0.1	328

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TABLE G-2 BUILDING 506A PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506A	E M Barracks	219	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	220	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	221	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	223	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	224	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	225	1	S	F	1	40	2	10	20	168	1.0	0.1	874
506A	E M Barracks	226	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	227	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	228	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	229	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	230	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	231	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	232	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	233	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	234	1	S	F	1	40	2	10	10	168	1.0	0.1	874
506A	E M Barracks	235	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	236	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	237	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	238	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	239	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	240	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	241	1	S	F	1	40	19	10	10	168	1.0	1.0	8,299
506A	E M Barracks	301	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	302	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	303	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	304	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	305	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	306	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	308	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	309	15	S	I	1	60	1	0	10	17	0.8	0.1	39
506A	E M Barracks	310	9	S	F	2	40	2	20	20	84	0.8	0.2	655
506A	E M Barracks	311	9	S	F	2	40	2	20	20	84	0.8	0.2	655

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TABLE G-2 BUILDING 506A PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506A	E M Barracks	313	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	314	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	315	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	316	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	317	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	318	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	319	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	320	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	321	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	322	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	323	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	324	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	325	1	S	F	1	40	2	10	10	168	0.8	0.1	655
506A	E M Barracks	326	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	327	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	328	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	329	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	330	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	331	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	332	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	333	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	334	1	S	F	1	40	2	10	10	168	0.8	0.1	655
506A	E M Barracks	335	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	336	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	337	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	338	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	339	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	340	9	S	F	2	40	1	20	20	84	0.8	0.1	328
506A	E M Barracks	341	1	S	F	1	40	19	10	10	168	0.8	1.0	6,224

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TOTAL BLDG TOTAL BLDG

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TABLE G-2 BUILDING 506A PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
	(kWH/Yr)	LOAD (kW)	CONN (W/SF)	SQ FEET										
	92,912	24.8	0.8	32,220										

LIGHTING LEGEND

Task Code		Fixture Type
1	Corridors	R - Recessed
2	Kitchens	S - Surface
3	Dining	P - Pendant
4	Offices general	O - Other
5	Offices ledgers	
6	Offices drafting	Lamp Type
7	Laundry	I - Incandescent
8	Toilets	F - Fluorescent
9	Sleeping quarters	
10	Supply room	
11	Repair shop	
12	Storage room	
13	Retail store	
14	Shower	
15	Janitors closet	
16	Reception	
17	Recreation room	
18	TV room	

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TABLE G-3 BUILDING 506B PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506B	E M Barracks	100	7	S	F	4	40	2	40	60	56	1.0	0.40	1,165
506B	E M Barracks	101	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	101	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	102	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	102	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	103	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	103	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	104	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	104	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	105	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	105	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	106	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	106	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	107	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	107	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	108	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	108	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	109	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	109	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	110	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	110	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	111	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	111	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	112	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	112	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	113	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	113	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	114	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	114	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	115	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	115	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	116	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	116	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	117	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	117	8	S	I	4	60	1	0	20	84	0.8	0.24	786

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TABLE G-3 BUILDING 506B PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506B	E M Barracks	118	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	118	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	119	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	119	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	120	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	120	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	121	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	121	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	122	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	122	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	123	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	123	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	124	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	124	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	125	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	125	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	126	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	126	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	127	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	127	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	128	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	128	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	129	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	129	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	130	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	130	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	131	1	S	F	2	40	2	20	10	168	1.0	0.20	1,747
506B	E M Barracks	132	1	S	F	2	40	18	20	10	168	1.0	1.80	15,725
506B	E M Barracks	132	1	S	F	4	40	1	40	10	168	1.0	0.20	1,747
506B	E M Barracks	133	14	S	I	1	60	1	0	10	17	0.8	0.06	42
506B	E M Barracks	134	1	S	F	2	40	2	20	10	168	1.0	0.20	1,747
506B	E M Barracks	135	3	R	F	2	40	8	20	40	126	0.8	0.80	3,931
506B	E M Barracks	136	12	R	F	2	40	4	20	30	17	0.8	0.40	280
506B	E M Barracks	137	16	R	F	2	40	3	20	30	168	1.0	0.30	2,621
506B	E M Barracks	138	4	R	F	4	40	8	40	70	60	0.8	1.60	3,774

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TABLE G-3 BUILDING 506B PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506B	E M Barracks	139	4	R	F	4	40	2	40	70	60	0.8	0.40	943
506B	E M Barracks	140	17	S	I	1	60	1	0	10	17	0.8	0.06	42
506B	E M Barracks	141	17	S	F	2	40	1	20	30	17	0.8	0.10	70
506B	E M Barracks	142	17	S	F	2	40	2	20	30	17	0.8	0.20	140
506B	E M Barracks	143	8	S	F	2	40	2	20	20	84	0.8	0.20	655
506B	E M Barracks	143	8	S	I	1	60	1	0	20	84	0.8	0.06	197
506B	E M Barracks	144	8	S	F	2	40	1	20	20	84	0.8	0.10	328
506B	E M Barracks	145	12	S	F	2	40	1	20	20	17	0.8	0.10	70
506B	E M Barracks	146	4	S	F	2	40	10	20	40	60	0.8	1.00	2,359
506B	E M Barracks	200	12	LOCK	LOCK	LOCKED	LOCKED	LOCKED	LOCKED	LOCKED	LOCKED	LOCKED	0.00	0
506B	E M Barracks	201	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	201	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	202	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	202	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	203	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	203	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	204	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	204	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	205	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	205	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	206	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	206	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	207	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	207	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	208	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	208	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	209	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	209	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	210	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	210	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	211	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	211	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	212	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	212	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	213	8	S	I	4	60	1	0	20	84	0.8	0.24	839

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TABLE G-3 BUILDING 506B PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506B	E M Barracks	213	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	214	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	214	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	215	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	215	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	216	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	216	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	217	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	217	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	218	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	218	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	219	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	219	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	220	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	220	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	221	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	221	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	222	8	S	I	4	60	1	0	20	84	0.8	0.24	839
506B	E M Barracks	222	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	223	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	223	9	S	I	3	60	1	0	20	84	0.8	0.18	590
506B	E M Barracks	224	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	224	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	225	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	225	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	226	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	226	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	227	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	227	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	228	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	228	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	229	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	229	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	230	2	S	F	2	40	3	20	20	126	0.8	0.30	1,474
506B	E M Barracks	231	12	S	F	2	40	1	20	20	17	0.8	0.10	70

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Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506B	E M Barracks	232	1	S	F	2	40	3	20	10	168	1.0	0.30	2,621
506B	E M Barracks	233	12	NO LT	NO LT	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	0.00	0
506B	E M Barracks	234	14	S	I	1	60	1	0	10	17	0.8	0.06	42
506B	E M Barracks	235	1	S	F	2	40	16	20	10	168	1.0	1.60	13,978
506B	E M Barracks	236	1	S	F	4	40	1	40	20	168	1.0	0.20	1,747
506B	E M Barracks	236	1	S	F	2	40	2	20	20	168	1.0	0.20	1,747
506B	E M Barracks	237	14	S	I	1	60	1	0	10	17	0.8	0.06	42
506B	E M Barracks	238	12	NO LT	NO LT	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	0.00	0
506B	E M Barracks	300	12	NO LT	NO LT	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	0.00	0
506B	E M Barracks	301	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	301	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	302	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	302	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	303	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	303	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	304	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	304	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	305	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	305	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	306	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	306	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	307	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	307	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	308	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	308	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	309	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	309	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	310	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	310	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	311	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	311	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	312	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	312	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	313	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	313	9	S	I	3	60	1	0	20	84	0.8	0.18	629

TABLE G-3 BUILDING 506B PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506B	E M Barracks	314	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	314	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	315	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	315	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	316	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	316	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	317	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	317	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	318	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	318	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	319	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	319	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	320	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	320	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	321	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	321	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	322	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	322	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	323	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	323	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	324	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	324	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	325	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	325	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	326	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	326	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	327	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	327	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	328	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	328	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	329	8	S	I	4	60	1	0	20	84	0.8	0.24	786
506B	E M Barracks	329	9	S	I	3	60	1	0	20	84	0.8	0.18	629
506B	E M Barracks	330	2	S	F	2	40	3	20	20	126	0.8	0.30	1,474
506B	E M Barracks	331	12	S	F	2	40	1	20	20	17	0.8	0.10	70
506B	E M Barracks	332	1	S	F	2	40	3	20	10	168	1.0	0.30	2,621

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TABLE G-3 BUILDING 506B PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506B	E M Barracks	333	12	NO LT	NO LT	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	0.00	0
506B	E M Barracks	334	14	S	I	1	60	1	0	10	17	0.8	0.06	42
506B	E M Barracks	335	1	S	F	2	40	16	20	10	168	1.0	1.60	13,978
506B	E M Barracks	336	1	S	F	2	40	3	20	10	168	1.0	0.30	2,621
506B	E M Barracks	337	14	S	I	1	NO BULB	1	0	NO BULB	17	0.8	0.00	0
506B	E M Barracks	338	15	NO LT	NO LT	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	NO LTS	0.00	0

TOTAL BLDG (kWH/Yr)	TOTAL LOAD (KW)	CONN (W/SF)	BLDG SQ FEET
203,768	51	1.1	44,264

LIGHTING LEDGEND

Task Code
1 Corridors
2 Kitchens
3 Dining
4 Offices general
5 Offices ledgers
6 Offices drafting
7 Laundry
8 Toilet
9 Sleeping quarters
10 Supply room
11 Repair shops
12 Storage rooms
13 Retail store
14 Janitors closet
15 Recreation room
16 Reception
17 Dark room

Fixture Type
R - Recessed
S - Surface
P - Pendant
O - Other

Lamp Type
I - Incandescent
F - Fluorescent

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TABLE G-4 BUILDING 506C PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
506C	E M Barracks	1	3	R	F	4	40	24	40	60	84	0.75	4.8	15,725
506C	E M Barracks	1	3	P	I	4	60	8	0	60	84	0.75	1.9	6,290
506C	E M Barracks	2	3	P	F	2	40	5	20	40	84	0.75	0.5	1,638
506C	E M Barracks	3	2	S	F	2	40	4	20	40	84	0.75	0.4	1,310
506C	E M Barracks	4	12	S	F	4	40	1	40	40	17	0.80	0.2	140
506C	E M Barracks	5	2	S	F	2	40	19	20	40	84	0.75	1.9	6,224
506C	E M Barracks	5	2	S	F	4	40	3	40	40	84	0.75	0.6	1,966

TOTAL BLDG (kWH/Yr)	TOTAL LOAD (kW)	CONN (W/SF)	BDLG SQ FEET
33,293	10	1.8	5,760

LIGHTING LEGEND

Task Code		Fixture Type
1	Corridors	R - Recessed
2	Kitchens	S - Surface
3	Dining	P - Pendant
4	Offices general	O - Other
5	Offices ledgers	
6	Offices drafting	Lamp Type
7	Laundry	I - Incadescent
8	Toilet	F - Fluorescent
9	Sleeping quarters	
10	Supply room	
11	Repair shops	
12	Storage room	

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TABLE G-5 BUILDING 2105 NORTHSIDE FIRST FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
2105	Range Opert Cent	1	1	R	F	2	40	2	20	40	168	1.0	0.20	1,747
2105	Range Opert Cent	10	4	R	F	3	40	6	30	40	80	0.9	0.90	3,370
2105	Range Opert Cent	11	4	R	F	3	40	8	30	50	80	0.9	1.20	4,493
2105	Range Opert Cent	12	4	R	F	3	40	2	30	40	80	0.9	0.30	1,123
2105	Range Opert Cent	13	4	R	F	3	40	2	30	40	80	0.9	0.30	1,123
2105	Range Opert Cent	14	4	R	F	3	40	2	30	40	80	0.9	0.30	1,123
2105	Range Opert Cent	15,16	4	R	F	3	40	13	30	40	80	0.9	1.95	7,301
2105	Range Opert Cent	17	4	R	F	3	40	8	30	40	80	0.9	1.20	4,493
2105	Range Opert Cent	18	4	R	F	4	40	2	40	60	80	0.9	0.40	1,498
2105	Range Opert Cent	19	4	R	F	3	40	3	30	60	80	0.9	0.45	1,685
2105	Range Opert Cent	2	4	R	F	4	40	8	40	80	80	0.9	1.60	5,990
2105	Range Opert Cent	20	1	R	F	2	40	4	20	20	168	1.0	0.40	3,494
2105	Range Opert Cent	21	1	B	I	1	50	8	0	5	168	1.0	0.40	3,494
2105	Range Opert Cent	22	1	R	F	2	40	4	20	20	168	1.0	0.40	3,494
2105	Range Opert Cent	23	4	R	F	2	40	6	20	50	80	0.9	0.60	2,246
2105	Range Opert Cent	24	4	R	F	2	40	7	20	42	80	0.9	0.70	2,621
2105	Range Opert Cent	25	1	R	F	2	40	4	20	20	168	1.0	0.40	3,494
2105	Range Opert Cent	26	1	R	F	2	40	2	20	20	168	1.0	0.20	1,747
2105	Range Opert Cent	27	1	R	F	2	40	7	20	20	168	1.0	0.70	6,115
2105	Range Opert Cent	2A	4	R	F	4	40	8	40	80	80	0.9	1.60	5,990
2105	Range Opert Cent	3,5,7	4	R	F	3	40	21	30	50	80	0.9	3.15	11,794
2105	Range Opert Cent	30	4	R	F	2	40	6	20	50	80	0.9	0.60	2,246
2105	Range Opert Cent	31	4	R	F	2	40	8	20	50	80	0.9	0.80	2,995
2105	Range Opert Cent	32	4	R	F	2	40	10	20	45	80	0.9	1.00	3,744
2105	Range Opert Cent	33	4	R	F	2	40	10	20	50	80	0.9	1.00	3,744
2105	Range Opert Cent	34	4	R	F	2	40	10	20	50	80	0.9	1.00	3,744
2105	Range Opert Cent	35	4	R	F	2	40	3	20	60	80	0.9	0.30	1,123
2105	Range Opert Cent	36	4	R	F	2	40	5	20	50	80	0.9	0.50	1,872
2105	Range Opert Cent	37	10	S	F	1	40	2	10	20	50	1.0	0.10	260
2105	Range Opert Cent	38	12	S	F	1	40	1	10	10	50	1.0	0.05	130
2105	Range Opert Cent	3A	4	R	F	4	40	4	40	60	80	0.9	0.80	2,995

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TABLE G-5 BUILDING 2105 NORTHSIDE FIRST FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
2105	Range Opert Cent	4	4	R	F	3	40	60	30	50	80	0.9	9.00	33,696
2105	Range Opert Cent	40	8	S	F	3	40	4	30	20	168	1.0	0.60	5,242
2105	Range Opert Cent	41	15	S	F	1	40	1	10	10	8	1.0	0.05	21
2105	Range Opert Cent	44	8	R	F	2	40	3	20	20	168	1.0	0.30	2,621
2105	Range Opert Cent	44	8	R	F	1	40	1	10	20	168	1.0	0.05	437
2105	Range Opert Cent	44	8	R	F	2	40U	3	20	20	168	1.0	0.06	524
2105	Range Opert Cent	45	4	R	F	4	40	16	40	50	80	0.9	3.20	11,981
2105	Range Opert Cent	46	4	R	F	3	40	4	30	60	80	0.9	0.60	2,246
2105	Range Opert Cent	47	4	R	F	4	40	2	40	70	80	0.9	0.40	1,498
2105	Range Opert Cent	48	4	R	F	3	40	8	30	60	80	0.9	1.20	4,493
2105	Range Opert Cent	50	4	R	F	4	40	16	40	50	80	0.9	3.20	11,981
2105	Range Opert Cent	52	4	R	F	3	40	25	30	60	80	0.9	3.75	14,040
2105	Range Opert Cent	53	4	R	F	2	40	2	20	40	80	0.9	0.20	749
2105	Range Opert Cent	54	4	R	F	4	40	2	40	80	80	0.9	0.40	1,498
2105	Range Opert Cent	55	4	R	F	4	40	2	40	70	80	0.9	0.40	1,498
2105	Range Opert Cent	56	4	R	F	4	40	2	40	70	80	0.9	0.40	1,498
2105	Range Opert Cent	58	14	R	F	2	40U	10	20	75	50	1.0	0.20	520
2105	Range Opert Cent	58A	14	R	I	1	75	27	0	75	50	1.0	2.03	5,265
2105	Range Opert Cent	59	4	R	F	3	40	22	30	60	80	0.9	3.30	12,355
2105	Range Opert Cent	6	4	R	F	3	40	6	30	65	80	0.9	0.90	3,370
2105	Range Opert Cent	60	4	R	F	3	40	8	30	60	80	0.9	1.20	4,493
2105	Range Opert Cent	61	4	R	F	3	40	3	30	50	80	0.9	0.45	1,685
2105	Range Opert Cent	62	4	R	F	3	40	3	30	50	80	0.9	0.45	1,685
2105	Range Opert Cent	63	4	R	F	2	40	10	20	60	80	0.9	1.00	3,744
2105	Range Opert Cent	8	4	R	F	4	40	6	40	70	80	0.9	1.20	4,493
2105	Range Opert Cent	9	4	R	F	2	40	12	20	25	80	0.9	1.20	4,493

TOTAL BLDG (kWH/Yr)	TOTAL LOAD (kW)	CONN (W/SF)	BLDG SQ FEET
237,413	59.2	1.9	30,398

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TABLE G-5 BUILDING 2105 NORTHSIDE FIRST FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)

LIGHTING LEGEND

Task Code		Fixture Type
1	Corridors	R - Recessed
2	Kitchens	S - Surface
3	Dining	P - Pendant
4	Offices general	B - Bollard
5	Offices ledger	O - Other
6	Offices drafting	
7	Laundry	Lamp Type
8	Toilet	I - Incandescent
9	Sleeping quarters	F - Fluorescent
10	Supply room	
11	Repair shop	
12	Storage room	
13	Retail store	
14	Lobby reception	
15	Janitors closet	

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TABLE G-6 BUILDING 2105 SOUTHSIDE FIRST FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
2105	Range Opert Cent	105A	11	P	F	2	40	14	20	40	50	1.0	1.40	3,640
2105	Range Opert Cent	105B	4	R	F	2	40	2	20	65	80	0.9	0.20	749
2105	Range Opert Cent	108A	11	P	F	2	40	26	20	60	50	1.0	2.60	6,760
2105	Range Opert Cent	108B	11	P	F	2	40	9	20	46	50	1.0	0.90	2,340
2105	Range Opert Cent	117A	4	R	F	3	40	3	30	60	80	0.9	0.45	1,685
2105	Range Opert Cent	117B	4	R	F	3	40	1	30	40	80	0.9	0.15	562
2105	Range Opert Cent	117C	4	R	F	3	40	1	30	40	80	0.9	0.15	562
2105	Range Opert Cent	119A	4	R	F	4	40	2	40	60	80	0.9	0.40	1,498
2105	Range Opert Cent	119B	4	P	F	2	40	7	20	30	80	0.9	0.70	2,621
2105	Range Opert Cent	120A	16	S	I	1	60	1	0	20	50	0.5	0.06	78
2105	Range Opert Cent	120B	11	R	F	4	40	5	40	70	50	1.0	1.00	2,600
2105	Range Opert Cent	122A	11	P	F	2	40	17	20	40	50	1.0	1.70	4,420
2105	Range Opert Cent	122B	11	R	F	4	40	3	40	80	50	1.0	0.60	1,560
2105	Range Opert Cent	136A	8	S	F	2	40	2	20	40	168	1.0	0.20	1,747
2105	Range Opert Cent	136B	8	S	F	1	40	2	10	40	168	1.0	0.10	874
2105	Range Opert Cent	139A	8	S	F	2	40	2	20	40	168	1.0	0.20	1,747
2105	Range Opert Cent	139B	8	S	F	1	40	2	10	40	168	1.0	0.10	874
2105	Range Opert Cent	79A	4	R	F	3	40	2	30	50	80	0.9	0.30	1,123
2105	Range Opert Cent	79B	4	R	F	3	40	2	30	50	80	0.9	0.30	1,123
2105	Range Opert Cent	83A	14	R	I	1	150	17	0	70	50	1.0	2.55	6,630
2105	Range Opert Cent	83B	12	S	F	2	40	2	20	50	50	1.0	0.20	520
2105	Range Opert Cent	85A	8	S	F	2	40	2	20	20	168	1.0	0.20	1,747
2105	Range Opert Cent	85B	8	S	F	2	40	2	20	20	168	1.0	0.20	1,747
2105	Range Opert Cent	85C	4	R	F	3	40	4	30	50	80	0.9	0.60	2,246
2105	Range Opert Cent	86A	4	R	I	1	150	1	0	50	80	0.9	0.15	562
2105	Range Opert Cent	87A	15	R	F	3	40	8	30	50	8	1.0	1.20	499
2105	Range Opert Cent	87B	15	R	I	1	150	7	0	50	8	1.0	1.05	437
2105	Range Opert Cent	87C	4	R	F	3	40	2	30	40	80	0.9	0.30	1,123
2105	Range Opert Cent	90A	3	R	F	3	40	15	30	40	50	0.8	2.25	4,680
2105	Range Opert Cent	91A	2	R	F	3	40	7	30	50	50	0.8	1.05	2,048
2105	Range Opert Cent	91B	2	R	F	2	40U	1	20	50	50	0.8	0.02	39
2105	Range Opert Cent	91C	2	R	I	1	60	8	0	40	50	0.8	0.48	936
2105	Range Opert Cent	94A	12	R	F	3	40	2	30	50	50	1.0	0.30	780
2105	Range Opert Cent	94B	4	R	F	3	40	4	30	100	80	0.9	0.60	2,246

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TABLE G-6 BUILDING 2105 SOUTHSIDE FIRST FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
2105	Range Opert Cent	65	1	S	F	1	40	2	10	10	168	1.0	0.10	874
2105	Range Opert Cent	66	1	R	F	2	40	5	20	20	168	1.0	0.50	4,368
2105	Range Opert Cent	67	14	S	F	1	40	2	10	10	50	1.0	0.10	260
2105	Range Opert Cent	68	1	R	F	2	40	3	20	20	168	1.0	0.30	2,621
2105	Range Opert Cent	69	4	R	F	2	40	8	20	40	80	0.9	0.80	2,995
2105	Range Opert Cent	70	4	R	F	4	40	2	40	70	80	0.9	0.40	1,498
2105	Range Opert Cent	71	4	R	F	4	40	2	40	70	80	0.9	0.40	1,498
2105	Range Opert Cent	72	4	R	F	3	40	8	30	50	80	0.9	1.20	4,493
2105	Range Opert Cent	73	4	R	F	3	40	4	30	40	80	0.9	0.60	2,246
2105	Range Opert Cent	74	4	S	F	2	40	33	20	50	80	0.9	3.30	12,355
2105	Range Opert Cent	75	4	R	F	3	40	2	30	60	80	0.9	0.30	1,123
2105	Range Opert Cent	76	4	R	F	3	40	3	30	50	80	0.9	0.45	1,685
2105	Range Opert Cent	77	4	R	F	3	40	3	30	50	80	0.9	0.45	1,685
2105	Range Opert Cent	78	1	R	F	3	40	4	30	20	168	1.0	0.60	5,242
2105	Range Opert Cent	80	4	R	F	3	40	2	30	50	80	0.9	0.30	1,123
2105	Range Opert Cent	81	4	R	F	3	40	2	30	50	80	0.9	0.30	1,123
2105	Range Opert Cent	82	1	R	F	1	40	1	10	10	168	1.0	0.05	437
2105	Range Opert Cent	83	14	R	F	2	40U	6	20	70	50	1.0	0.12	312
2105	Range Opert Cent	84	1	R	F	3	40	4	30	20	168	1.0	0.60	5,242
2105	Range Opert Cent	86	4	R	F	3	40	2	30	50	80	0.9	0.30	1,123
2105	Range Opert Cent	88	4	R	F	2	40	3	20	60	80	0.9	0.30	1,123
2105	Range Opert Cent	89	1	B	I	1	50	9	0	10	168	1.0	0.45	3,931
2105	Range Opert Cent	92	2	R	F	2	40	2	20	40	50	0.8	0.20	390
2105	Range Opert Cent	93	12	S	F	4	40	2	40	70	50	1.0	0.40	1,040
2105	Range Opert Cent	95	4	R	F	2	40	4	20	100	80	0.9	0.40	1,498
2105	Range Opert Cent	96	4	R	F	2	40	4	20	100	80	0.9	0.40	1,498
2105	Range Opert Cent	97	4	R	F	2	40	4	20	100	80	0.9	0.40	1,498
2105	Range Opert Cent	98	1	R	F	3	40	1	30	50	168	1.0	0.15	1,310
2105	Range Opert Cent	99	4	R	F	4	40	2	40	100	80	0.9	0.40	1,498
2105	Range Opert Cent	100	4	R	F	4	40	28	40	80	80	0.9	5.60	20,966
2105	Range Opert Cent	101	4	R	F	3	40	9	30	55	80	0.9	1.35	5,054
2105	Range Opert Cent	102	4	R	F	2	40	4	20	100	80	0.9	0.40	1,498
2105	Range Opert Cent	103	4	R	F	2	40	4	20	100	80	0.9	0.40	1,498
2105	Range Opert Cent	104	4	R	F	3	40	4	30	100	80	0.9	0.60	2,246

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TABLE G-6 BUILDING 2105 SOUTHSIDE FIRST FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
2105	Range Opert Cent	106	11	P	F	2	40	4	20	50	50	1.0	0.40	1,040
2105	Range Opert Cent	109	16	S	F	2	40	1	20	60	50	0.5	0.10	130
2105	Range Opert Cent	110	16	S	F	2	40	1	20	60	50	0.5	0.10	130
2105	Range Opert Cent	111	4	S	F	2	40	2	20	60	80	0.9	0.20	749
2105	Range Opert Cent	112	4	R	F	3	40	5	30	50	80	0.9	0.75	2,808
2105	Range Opert Cent	113	4	R	F	3	40	2	30	60	80	0.9	0.30	1,123
2105	Range Opert Cent	114	4	R	F	4	40	2	40	100	80	0.9	0.40	1,498
2105	Range Opert Cent	115	4	R	F	4	40	2	40	100	80	0.9	0.40	1,498
2105	Range Opert Cent	116	4	R	F	3	40	2	30	60	80	0.9	0.30	1,123
2105	Range Opert Cent	118	4	R	F	3	40	3	30	60	80	0.9	0.45	1,685
2105	Range Opert Cent	121	4	R	F	3	40	2	30	60	80	0.9	0.30	1,123
2105	Range Opert Cent	124	1	R	F	2	40U	3	20	20	168	1.0	0.06	524
2105	Range Opert Cent	125	4	R	F	2	40	2	20	65	80	0.9	0.20	749
2105	Range Opert Cent	126	4	R	F	2	40	2	20	50	80	0.9	0.20	749
2105	Range Opert Cent	127	4	R	F	3	40	4	30	50	80	0.9	0.60	2,246
2105	Range Opert Cent	128	4	R	F	4	40	4	40	80	80	0.9	0.80	2,995
2105	Range Opert Cent	130	1	R	F	2	40	5	20	20	168	1.0	0.50	4,368
2105	Range Opert Cent	131	8	R	F	2	40U	1	20	20	168	1.0	0.02	175
2105	Range Opert Cent	132	8	R	F	2	40	2	20	30	168	1.0	0.20	1,747
2105	Range Opert Cent	133	8	S	F	2	40	2	20	30	168	1.0	0.20	1,747
2105	Range Opert Cent	134	8	S	I	1	60	2	0	10	168	1.0	0.12	1,048
2105	Range Opert Cent	137	15	S	F	1	40	1	10	10	8	1.0	0.05	21
2105	Range Opert Cent	138	8	S	F	2	40	1	20	10	168	1.0	0.10	874
2105	Range Opert Cent	140	8	S	F	2	40	8	20	30	168	1.0	0.80	6,989
2105	Range Opert Cent	141	8	S	I	1	60	4	0	10	168	1.0	0.24	2,097
2105	Range Opert Cent	142	1	S	F	3	40	3	30	20	168	1.0	0.45	3,931
2105	Range Opert Cent	145	1	R	F	2	40	1	20	10	168	1.0	0.10	874
2105	Range Opert Cent	146	1	S	F	1	40	2	10	10	168	1.0	0.10	874

TOTAL BLDG (kWH/Yr)	TOTAL LOAD (kW)	CONN (W/SF)	BLDG SQ FEET
205,064	53.72	2.2	24,640

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TABLE G-6 BUILDING 2105 SOUTHSIDE FIRST FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)

LIGHTING LEGEND

	Task Code	Fixture Type
1	Corridors	R - Recessed
2	Kitchens	S - Surface
3	Dining	P - Pendant
4	Offices general	O - Other
5	Offices ledger	
6	Offices drafting	Lamp Type
7	Laundry	I - Incandescent
8	Toilet	F - Fluorescent
9	Sleeping quarter	
10	Supply room	
11	Repair shop	
12	Storage room	
13	Retail store	
14	Closet	
15	Janitors closet	
16	Dark room	

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TABLE G-7 BUILDING 2105 SOUTHSIDE SECOND FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
2105	Range Opert Cent	165/166/1	4	R	F	2	40	16	20	50	80	0.9	1.60	5,990
2105	Range Opert Cent	170/172	4	R	F	2	40	12	20	50	80	0.9	1.20	4,493
2105	Range Opert Cent	179/180/1	4	R	F	2	40	19	20	40	80	0.9	1.90	7,114
2105	Range Opert Cent	204/206	4	R	F	2	40	43	20	40	80	0.9	4.30	16,099
2105	Range Opert Cent	229A	14	R	F	4	40	12	40	75	50	1.0	2.40	6,240
2105	Range Opert Cent	229B	14	R	F	2	40	3	20	75	50	1.0	0.30	780
2105	Range Opert Cent	229C	14	R	I	1	75	2	10	75	50	1.0	0.17	442
2105	Range Opert Cent	234A	8	S	F	2	40	1	20	20	168	11.0	0.10	9,610
2105	Range Opert Cent	234B	8	S	F	1	40	2	10	20	168	1.0	0.10	874
2105	Range Opert Cent	236A	8	S	F	2	40	3	20	20	168	1.0	0.30	2,621
2105	Range Opert Cent	236B	8	S	F	1	40	2	10	20	168	1.0	0.10	874
2105	Range Opert Cent	150	1	S	F	1	40	1	10	10	168	1.0	0.05	437
2105	Range Opert Cent	151	1	R	F	2	40	2	20	20	168	1.0	0.20	1,747
2105	Range Opert Cent	152	12	S	F	1	40	2	10	10	50	1.0	0.10	260
2105	Range Opert Cent	153	12	S	F	1	40	2	10	10	50	1.0	0.10	260
2105	Range Opert Cent	154	4	R	F	4	40	3	40	60	80	0.9	0.60	2,246
2105	Range Opert Cent	155	16	R	F	2	40	1	20	10	8	1.0	0.10	42
2105	Range Opert Cent	156	1	R	F	2	40	5	20	10	168	1.0	0.50	4,368
2105	Range Opert Cent	157	4	R	F	2	40	7	20	50	80	0.9	0.70	2,621
2105	Range Opert Cent	158	4	R	F	2	40	9	20	50	80	0.9	0.90	3,370
2105	Range Opert Cent	159	4	R	F	2	40	5	20	50	80	0.9	0.50	1,872
2105	Range Opert Cent	160	4	R	F	2	40	17	20	48	80	0.9	1.70	6,365
2105	Range Opert Cent	161	4	R	F	2	40	3	20	40	80	0.9	0.30	1,123
2105	Range Opert Cent	162	4	R	F	2	40	3	20	40	80	0.9	0.30	1,123
2105	Range Opert Cent	163	4	R	F	2	40	3	20	40	80	0.9	0.30	1,123
2105	Range Opert Cent	164	4	R	F	2	40	6	20	40	80	0.9	0.60	2,246
2105	Range Opert Cent	167	4	R	F	2	40	5	20	40	80	0.9	0.50	1,872
2105	Range Opert Cent	168	4	R	F	2	40	3	20	40	80	0.9	0.30	1,123
2105	Range Opert Cent	171	4	R	F	2	40	3	20	40	80	0.9	0.30	1,123
2105	Range Opert Cent	173	4	R	F	2	40	3	20	40	80	0.9	0.30	1,123
2105	Range Opert Cent	174	4	R	F	2	40	5	20	45	80	0.9	0.50	1,872

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TABLE G-7 BUILDING 2105 SOUTHSIDE SECOND FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
2105	Range Opert Cent	175	4	R	F	2	40	5	20	45	80	0.9	0.50	1,872
2105	Range Opert Cent	176	4	R	F	2	40	3	20	40	80	0.9	0.30	1,123
2105	Range Opert Cent	177	4	R	F	2	40	6	20	50	80	0.9	0.60	2,246
2105	Range Opert Cent	178	1	R	F	2	40	7	20	10	168	1.0	0.70	6,115
2105	Range Opert Cent	182	4	R	F	2	40	3	20	40	80	0.9	0.30	1,123
2105	Range Opert Cent	183	4	R	F	2	40	6	20	60	80	0.9	0.60	2,246
2105	Range Opert Cent	184	4	R	F	2	40	5	20	45	80	0.9	0.50	1,872
2105	Range Opert Cent	186	4	R	F	2	40	8	20	60	80	0.9	0.80	2,995
2105	Range Opert Cent	187	4	R	F	2	40	3	20	40	80	0.9	0.30	1,123
2105	Range Opert Cent	188	4	R	F	2	40	5	20	45	80	0.9	0.50	1,872
2105	Range Opert Cent	189	4	R	F	2	40	15	20	30	80	0.9	1.50	5,616
2105	Range Opert Cent	190	4	R	F	4	40	3	40	60	80	0.9	0.60	2,246
2105	Range Opert Cent	191	12	R	F	2	40	1	20	30	50	1.0	0.10	260
2105	Range Opert Cent	192	4	S	F	4	40	6	40	60	80	0.9	1.20	4,493
2105	Range Opert Cent	193	12	R	I	1	60	1	0	20	50	1.0	0.06	156
2105	Range Opert Cent	194	4	R	F	3	40	6	30	50	80	0.9	0.90	3,370
2105	Range Opert Cent	195	4	R	F	2	40	5	20	45	80	0.9	0.50	1,872
2105	Range Opert Cent	196	4	R	F	2	40	4	20	40	80	0.9	0.40	1,498
2105	Range Opert Cent	197	4	R	F	2	40	5	20	50	80	0.9	0.50	1,872
2105	Range Opert Cent	198	4	R	F	2	40	6	20	50	80	0.9	0.60	2,246
2105	Range Opert Cent	199	4	R	F	2	40	13	20	30	80	0.9	1.30	4,867
2105	Range Opert Cent	200	4	R	F	2	40	12	20	30	80	0.9	1.20	4,493
2105	Range Opert Cent	201	4	R	F	2	40	5	20	50	80	0.9	0.50	1,872
2105	Range Opert Cent	202	4	R	F	2	40	3	20	30	80	0.9	0.30	1,123
2105	Range Opert Cent	203	4	R	I	1	100	10	0	30	80	0.9	1.00	3,744
2105	Range Opert Cent	205	4	R	F	2	40	5	20	50	80	0.9	0.50	1,872
2105	Range Opert Cent	207	4	R	F	4	40	4	40	50	80	0.9	0.80	2,995
2105	Range Opert Cent	208	4	R	F	2	40	5	20	50	80	0.9	0.50	1,872
2105	Range Opert Cent	209	4	R	F	2	40	42	20	50	80	0.9	4.20	15,725
2105	Range Opert Cent	210	4	R	F	2	40	2	20	30	80	0.9	0.20	749
2105	Range Opert Cent	211	4	R	F	2	40	2	20	30	80	0.9	0.20	749

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TABLE G-7 BUILDING 2105 SOUTHSIDE SECOND FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
2105	Range Opert Cent	212	4	R	F	2	40	9	20	60	80	0.9	0.90	3,370
2105	Range Opert Cent	213	4	R	F	2	40	4	20	40	80	0.9	0.40	1,498
2105	Range Opert Cent	214	4	R	F	1	40	5	10	50	80	0.9	0.25	936
2105	Range Opert Cent	215	1	S	F	2	40	1	20	10	168	1.0	0.10	874
2105	Range Opert Cent	216	4	R	F	2	40	5	20	50	80	0.9	0.50	1,872
2105	Range Opert Cent	217	4	R	F	2	40	8	20	50	80	0.9	0.80	2,995
2105	Range Opert Cent	218	4	R	F	2	40	47	20	60	80	0.9	4.70	17,597
2105	Range Opert Cent	219	4	R	F	2	40	3	20	30	80	0.9	0.30	1,123
2105	Range Opert Cent	220	4	R	F	2	40	3	20	30	80	0.9	0.30	1,123
2105	Range Opert Cent	221	4	R	F	2	40	5	20	50	80	0.9	0.50	1,872
2105	Range Opert Cent	222	14	R	F	2	40	8	20	60	50	1.0	0.80	2,080
2105	Range Opert Cent	223	1	R	F	2	40	2	20	10	168	1.0	0.20	1,747
2105	Range Opert Cent	225	12	S	F	1	40	1	10	10	50	1.0	0.05	130
2105	Range Opert Cent	226	1	S	MV	1	100	8	28	10	168	1.0	1.02	8,946
2105	Range Opert Cent	227	12	S	F	1	40	1	10	10	50	1.0	0.05	130
2105	Range Opert Cent	228	1	R	F	2	40	2	20	10	168	1.0	0.20	1,747
2105	Range Opert Cent	230	14	S	F	2	40	3	20	40	50	1.0	0.30	780
2105	Range Opert Cent	231	1	R	F	2	40	4	20	10	168	1.0	0.40	3,494
2105	Range Opert Cent	232	8	R	F	2	40	2	20	20	168	1.0	0.20	1,747
2105	Range Opert Cent	233	8	R	F	2	40	1	20	20	168	1.0	0.10	874
2105	Range Opert Cent	235	8	S	F	2	40	1	20	20	168	1.0	0.10	874
2105	Range Opert Cent	237	15	S	F	1	40	1	10	10	8	1.0	0.05	21

TOTAL BLDG (kWH/Yr)	TOTAL LOAD	CONN	BLDG SQ
233,560	55.704	2.26	24,640

LIGHTING LEDGEND

Task Code　　Fixture Type

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TABLE G-7 BUILDING 2105 SOUTHSIDE SECOND FLOOR PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
1	Corridors	R - Recessed												
2	Kitchens	S - Surface												
3	Dining	P - Pendant												
4	Offices general	O - Other												
5	Offices ledger													
6	Offices drafting	Lamp Type												
7	Laundry	I - Incandescent												
8	Toilets	F - Fluorescent												
9	Sleeping quarters	MV - Mercury vapor												
10	Supply room													
11	Repair shop													
12	Storage room													
13	Retail store													
14	Conference room													
15	Janitors closet													
16	Copy room													

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TABLE G-8 BUILDING 3482 PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
3482	Test Prep Facility	101	12	P	I	1	200	9	0	40	50	1.0	1.80	4,680
3482	Test Prep Facility	102	12	P	I	1	200	2	0	40	50	1.0	0.40	1,040
3482	Test Prep Facility	103	12	P	I	1	200	4	0	40	50	1.0	0.80	2,080
3482	Test Prep Facility	104	12	P	I	1	200	9	0	40	50	1.0	1.80	4,680
3482	Test Prep Facility	105	12	P	I	1	200	8	0	40	50	1.0	1.60	4,160
3482	Test Prep Facility	106	4	P	I	1	200	2	0	40	50	1.0	0.40	1,040
3482	Test Prep Facility	107	4	P	I	1	200	2	0	40	50	1.0	0.40	1,040
3482	Test Prep Facility	108	12	P	I	1	200	9	0	40	50	1.0	1.80	4,680
3482	Test Prep Facility	109	12	P	I	1	200	6	0	40	50	1.0	1.20	3,120
3482	Test Prep Facility	110	12	P	I	1	200	6	0	40	50	1.0	1.20	3,120
3482	Test Prep Facility	111	12	P	I	1	200	6	0	40	50	1.0	1.20	3,120
3482	Test Prep Facility	112	1	P	I	1	200	38	0	40	50	1.0	7.60	19,760
3482	Test Prep Facility	113	12	P	I	1	200	6	0	40	50	1.0	1.20	3,120
3482	Test Prep Facility	114	12	P	I	1	200	6	0	40	50	1.0	1.20	3,120
3482	Test Prep Facility	115	12	P	I	1	200	6	0	40	50	1.0	1.20	3,120
3482	Test Prep Facility	116	12	P	I	1	200	6	0	40	50	1.0	1.20	3,120
3482	Test Prep Facility	117	12	P	I	1	200	6	0	40	50	1.0	1.20	3,120
3482	Test Prep Facility	118	8	S	I	1	200	1	0	10	50	1.0	0.20	520
3482	Test Prep Facility	119	8	S	I	1	200	1	0	10	50	1.0	0.20	520
3482	Test Prep Facility	120	14	P	I	1	200	6	0	40	50	1.0	1.20	3,120
3482	Test Prep Facility	121	12	P	I	1	200	6	0	40	50	1.0	1.20	3,120
3482	Test Prep Facility	122	12	P	I	1	200	9	0	40	50	1.0	1.80	4,680
3482	Test Prep Facility	123	12	P	I	1	200	9	0	40	50	1.0	1.80	4,680
3482	Test Prep Facility	124	12	P	I	1	200	9	0	40	50	1.0	1.80	4,680

TOTAL BLDG (kWH/Yr)	TOTAL LOAD (kW)	CONN (W/SF)	BLDG SQ FEET

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TABLE G-8 BUILDING 3482 PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
	84,760	32.6	2.3	13,997										

LIGHTING LEGEND

Task Code		Fixture Type
1	Corridors	R - Recessed
2	Kitchens	S - Surface
3	Dining	P - Pendant
4	Offices general	O - Other
5	Offices ledger	
6	Offices drafting	Lamp Type
7	Laundry	I - Incandescent
8	Toilet	F - Fluorescent
9	Sleeping quarters	
10	Supply room	
11	Repair shop	
12	Storage room	
13	Retail store	

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TABLE G-9 BUILDING 3490 PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
3490	Weapon Eval Fac	01	11	P	MH	2	400	38	110	60	80	0.8	34.58	115,082
3490	Weapon Eval Fac	02	11	P	MH	2	400	57	110	60	80	0.8	51.87	172,623
3490	Weapon Eval Fac	03	11	P	MH	2	400	60	110	60	80	0.8	54.60	181,709
3490	Weapon Eval Fac	04	11	P	MH	2	400	64	110	60	80	0.8	58.24	193,823
3490	Weapon Eval Fac	05	4	R	F	4	40	3	40	60	80	0.8	0.60	1,997
3490	Weapon Eval Fac	06	4	R	F	4	40	4	40	60	80	0.8	0.80	2,662
3490	Weapon Eval Fac	07A	4	R	F	4	40	6	40	60	80	0.8	1.20	3,994
3490	Weapon Eval Fac	07B	4	R	F	4	40	4	40	60	80	0.8	0.80	2,662
3490	Weapon Eval Fac	08	3	S	F	2	40	10	20	40	80	0.5	1.00	2,080
3490	Weapon Eval Fac	09	1	S	F	1	40	4	10	10	80	1.0	0.20	832
3490	Weapon Eval Fac	20A	3	S	F	2	40	4	20	40	80	0.8	0.40	1,331
3490	Weapon Eval Fac	20B	4	R	F	4	40	2	40	40	80	0.8	0.40	1,331
3490	Weapon Eval Fac	32A	4	R	F	4	40	8	40	60	80	0.8	1.60	5,325
3490	Weapon Eval Fac	32B	4	R	F	4	40	4	40	80	80	0.8	0.80	2,662
3490	Weapon Eval Fac	32C	4	R	F	4	40	4	40	80	80	0.8	0.80	2,662
3490	Weapon Eval Fac	32D	4	R	F	4	40	4	40	80	80	0.8	0.80	2,662
3490	Weapon Eval Fac	32E	1	R	F	1	40	3	10	40	80	1.0	0.15	624
3490	Weapon Eval Fac	10	1	S	F	1	40	3	10	10	80	1.0	0.15	624
3490	Weapon Eval Fac	11	14	S	I	1	60	1	0	10	80	0.8	0.06	200
3490	Weapon Eval Fac	12	8	S	F	2	40	1	20	40	80	0.8	0.10	333
3490	Weapon Eval Fac	13	8	S	F	1	40	3	10	20	80	0.8	0.15	499
3490	Weapon Eval Fac	14	8	S	F	2	40	1	20	40	80	0.8	0.10	333
3490	Weapon Eval Fac	15	8	S	F	1	40	9	10	20	80	0.8	0.45	1,498
3490	Weapon Eval Fac	16	8	R	F	2	40	2	20	20	80	0.8	0.20	666
3490	Weapon Eval Fac	17	8	S	F	1	40	1	10	10	80	0.8	0.05	166
3490	Weapon Eval Fac	18	10	P	F	2	40	19	20	40	80	0.5	1.90	3,952
3490	Weapon Eval Fac	19	15	R	F	BY MFG	BY MFG	BY MFG	BY MFG	PAINT	BOOTH	1.0	0.00	0
3490	Weapon Eval Fac	21	14	S	I	1	60	1	10	10	80	0.5	0.07	146
3490	Weapon Eval Fac	22	8	S	F	1	40	2	10	20	80	0.8	0.10	333
3490	Weapon Eval Fac	23	8	S	F	1	40	3	10	20	80	0.8	0.15	499
3490	Weapon Eval Fac	24	8	S	F	3	40	2	30	20	80	0.8	0.30	998

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TABLE G-9 BUILDING 3490 PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Room No	Task Code	Type Code	Lamp Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Demand Factor	Demand (kW)	Electric (kW/Yr)
3490	Weapon Eval Fac	25	8	S	F	2	40	1	20	20	80	0.8	0.10	333
3490	Weapon Eval Fac	26	8	S	I	1	60	1	0	10	80	0.8	0.06	200
3490	Weapon Eval Fac	27	4	R	F	2	40	20	20	40	80	0.8	2.00	6,656
3490	Weapon Eval Fac	28	11	P	F	2	40	18	20	40	80	0.8	1.80	5,990
3490	Weapon Eval Fac	29	11	P	F	2	40	16	20	40	80	0.8	1.60	5,325
3490	Weapon Eval Fac	30	10	S	F	2	40	20	20	40	80	0.8	2.00	6,656
3490	Weapon Eval Fac	31	10	S	F	2	40	20	20	40	80	0.8	2.00	6,656
3490	Weapon Eval Fac	32	10	P	F	2	40	25	20	60	80	0.8	2.50	8,320
3490	Weapon Eval Fac	33	12	S	I	1	100	4	0	10	80	0.5	0.40	832

TOTAL BLDG (KWH/YR)	TOTAL LOAD (KW)	CONN (W/SF)	BLDG SQ FEET
745,276	225	2.6	85,763

LIGHTING LEGEND

Task Code		Fixture Type
1	Corridors	R - Rec essed
2	Kitchens	S - Surf ace
3	Dining	P - Pen dant
4	Offices general	O - Oth er
5	Offices ledger	
6	Offices drafting	LampT ype
7	Laundry	I - Inca ndescent
8	Toilet	F - Flu orescent
9	Sleeping quarters	MH - M etal halide
10	Supply room	
11	Repair shop	
12	Storage room	
13	Retail store	
14	Janitors closet	
15	Paint booth	

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TABLE G-10 BUILDING 3510 PRESENT LIGHTING ENERGY USE

Bldg No	Building Name	Roo No	Task Cod	Type Code	Lam Type	Lamp/ Fixture	Watts/ Lamp	No of Fixtures	Ballast Load (W)	Measured Light (FC)	Fixture (Hr/Wk)	Deman Factor	Demand (kW)	Electric (kW/Yr)
3510	Ord Accept Test Fac	201	12	P	I	1	200	6	0	20	8	1.0	1.2	499
3510	Ord Accept Test Fac	202	12	P	I	1	200	6	0	20	8	1.0	1.2	499
3510	Ord Accept Test Fac	203	12	P	I	1	200	6	0	20	8	1.0	1.2	499

TOTAL BLDG (kWH/Yr)	TOT LOAD (kW)	CON D (W/S	BLDG SQ FEET
1,498	3.6	1.3	2,772

LIGHTING LEGEND

Task Code		Fixture Type
1	Corridors	R - Recessed
2	Kitchens	S - Surface
3	Dining	P - Pendant
4	Offices general	O - Other
5	Offices ledgers	
6	Offices drafting	Lamp Type
7	Laundry	I - Incandescent
8	Toilets	F - Fluorescent
9	Sleeping Quarters	
10	Supply room	
11	Repair shop	
12	Storage room	
13	Retail store	

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Appendix H

Lighting Retrofit Calculations

APPENDIX H

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Lighting Retrofit Calculations

Two types of energy saving retrofits are evaluated for study buildings:

- Lighting fixture modifications
- Lighting controls modifications

Specific measures evaluated for both types of retrofits include:

Lighting Retrofits Evaluated

Proj.	Description	Type	Unit Cost ($)
A	Retrofit Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp	Fixture	76.70
B	Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps	Fixture	83.55
C	Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps	Fixture	100.77
D	Retrofit Unit Cost: 4-Lamp Electronic Ballast & T8 Lamps	Fixture	167.10
E	New Fixture Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp	Fixture	287.53
F	New Fixture Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps	Fixture	331.47
G	New Fixture Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps — Explosion Proof	Fixture	2,715.67
H	Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector	Fixture	152.69
I	Retrofit Unit Cost: Occupancy Sensor Lighting Control — Ceiling Mounted	Control	298.55
J	Retrofit Unit Cost: Occupancy Sensor Lighting Control — Automatic Wall Switch	Control	130.18
K	New Fixture Unit Cost: 2-Lamp Compact Fluorescent 2 x 13W/5T4	Fixture	163.99
L	New Fixture Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps, 2' Surface Mount	Fixture	373.00
M	Install Switching for Assembly Rooms — Building 3482 (Total cost shown)	Control	13,589.19

Results of economic evaluations are summarized on Table H-1. Detailed cost estimates and catalog data for selected components are appended.

Fixture Retrofit Evaluations

Both lighting fixture modifications and replacements are considered. Most existing fluorescent fixtures use 40 watt T12 lamps and standard ballasts. (Some energy saving 34 watt lamps and energy saving ballasts are installed, but they do not predominate.) Room-by-room calculations of fixture modifications or replacements in each study building appear as Tables H-2 through H-11.

Retrofits A, B, C and D are one-for-one lamp and ballast replacements for existing fixtures. Retrofitting existing one-lamp fluorescent fixtures with electronic ballasts and 32 watt T8 lamps will reduce fixture input power by over 20 watts in standard core and coil ballasts.

Retrofit H includes the same type of ballast and lamp replacements as above and, in addition, requires installation of a specular reflector in the fixture. This allows 4-lamp fixtures to be converted to 3-lamp fixtures without reducing illumination levels.

New fluorescent fixtures are proposed to replace existing incandescent fixtures. Retrofit types F, G and L are developed for this purpose.

Energy savings and economic analysis calculations for either a fixture modification or replacement are the same:

Lighting Retrofit Evaluation Calculations

Label	Contents / Calculation Explanation
RET_TYP	Retrofit type (See schedule above)
KW_SVD	(E_KW) — (S_KW) = Demand savings (kW) from lighting retrofit (See note below)
KWH_SV	(E_KWH/Y — S_KWH/Y) + [S#FXTR * SHR/WK * 52 * (EW/LAMP + EBAL_W — SW/LAMP — SBAL_W)/100000] = = Electric savings from retrofit, including cooling energy savings based on EER of 10.0
PWR_$/Y	KWH_SVD * $0.083 = Annual electric power cost savings (Average YPG power cost)
PWR_LCC$	PWR_$/Y * 11.30 = Life cycle savings, Life of 15 years; UPV factor 4% & 4.5% discount rate
CONST$	@VLOOKUP(RET_TYP,RET_TABLE,2) = Construction cost from retrofit types schedule
SIOH	CONST$ * 0.120 = SIOH and design at 6% each of construction cost
REBATE	[-$8.15 * (E_KW — S-KW)] = Arizona Public Services rebate for lighting retrofit kW (demand) savings for partial requirements
INVE$T	@SUM(CONST$,SIOH,REBATE) = Total investment per ECIP guidance
O&M_$/Y	[@VLOOKUP(EL_TYPE,OLD,4) * EHR/WK * EL/FXTR * E#FXTR] — [@VLOOKUP(SL_TYPE,NEW,4) * SHR/WK * SL/FXTR * S#FXTR] = = Annual O&M savings (additional cost) for lamp replacements; refer to schedules OLD" and "NEW"
O&M_LC	(O&M_$/Y * 10.74) = Life cycle O&M cost for Life of 15 years; UPV factor 4% & 4.5% discount rate
TOT_$/Y	(O&M_$Y + PWR_$/Y) = Total annual cost savings
TOT_LCC$	(O&M_LCC$ + PWR_LCC$) = Total life cycle cost savings
SIR	(TOT_LCC$) / (INVE$T) = Savings-to-investment ratio
PAYBCK	(INVE$T) / (TOT_$/Y) = Payback period (years)

Note: Parameters shown above for existing and retrofit (savings) cases are indicated by prefixes: "E_" and "S_", respectively, corresponding to labels used above to explain lighting energy use calculations.

RET_TABLE refers to unit costs of various retrofits as summarized above. OLD and NEW refer to relamping costs as are summarized below.

Electric energy savings of proposed retrofits includes consideration of reduced space cooling demand due to lower heat rejection rates of lighting fixtures after modification. Electric power savings due to reduced cooling loads are, thus:

[(Existing Fixture Watts) — (Retrofit Fixture Watts)] * 3.413 = BTUH cooling load reduction

Applying an EER of 10.0 (a fairly conservative value based on field measurements), energy savings due to reduced cooling energy requirements are:

[BTUH Load Reduction) / (10.0 * 1,000 W/kW)] * (Operating Hrs/Yr) = kWH/Year saved

Relamping Costs for Existing Fixtures (OLD)

Fixture Type	Life (Hours)	Lamp Cost ($)	Hours per Lamp Change	Cost per Lamp-Hr ($)
Fluorescent	20,000	1.59	0.167	0.0170
Incandescent	750	1.75	0.083	0.2929

Relamping Costs for Retrofit Fixtures (NEW)

Retrofit Type	Life (Hours)	Lamp Cost ($)	Hours Per Lamp Change	Cost per Lamp-Hr ($)
A	20,000	4.50	0.167	0.0246
B	20,000	4.50	0.167	0.0246
C	20,000	4.50	0.167	0.0246
D	20,000	4.50	0.167	0.0246
E	20,000	4.50	0.167	0.0246
F	20,000	4.50	0.167	0.0246
G	20,000	4.50	0.167	0.0246
H	20,000	4.50	0.167	0.0246
I	—not lighting fixture retrofits—			
J	—not lighting fixture retrofits—			
K	10,000	10.00	0.083	0.0649
L	20,000	6.20	0.167	0.1036
M	—not lighting fixture retrofits—			
Hours per lamp change: F = 10 minutes; I = 5 minutes				
Cost/lamp-hour: .(lamp cost + hrs per lamp change * $29.69/MH / lamp life * 52)				

Controls Retrofits

Lighting control retrofits evaluated involve installing occupancy sensor switching in offices, conference rooms, bathrooms and other areas where lights are normally turned on for periods when no one is present. Two types of occupancy sensors are considered. A wall switch type sensor is the least expensive and simply replaces a small office's toggle switch. For larger offices and open areas, ceiling mounted sensors are evaluated. Ceiling mounted switches are more expensive since a relay and additional wiring are required. Detailed evaluations appear as Tables H-12 through H-19.

Energy savings of at least 25% have been achieved in many similar retrofits according to Arizona Public Service Company. This savings level is assumed for these evaluations. This figure may be low for many offices observed during field investigations conducted for the study. In Building 2105, for example, many offices and office areas were observed to be unoccupied at least 50% of the time (with lights left on). Manufacturers of occupancy sensor switches report savings of between 35% and 75% depending on the application.

Energy and cost savings are determined using the same formulae as are shown above for lighting energy use calculations. The operating hours per week are simply factored down.

TABLE H-1. SUMMARY OF BUILDING LIGHTING AND CONTROLS RETROFIT EVALUATIONS

Building Number	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	(LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC	Economic Meas SIR	Economic Meas Payback
Lighting Retrofits Recommended																
BUILDING 451	68	B	2.65	11,078	$919	$10,390	$5,681	$682	($32)	$6,332	($82)	($880)	$838	$9,510	1.50	7.56
BUILDING 451	11	H	0.86	3,675	$305	$3,447	$1,680	$202	($11)	$1,870	($26)	($284)	$279	$3,163	1.69	6.71
BUILDING 451	35	K	1.49	6,809	$565	$6,386	$5,740	$689	($9)	$6,420	$468	$5,029	$1,033	$11,415	1.78	6.21
BUILDING 506A	80	A	1.73	12,293	$1,020	$11,529	$6,136	$736	($15)	$6,858	($92)	($983)	$929	$10,547	1.54	7.38
BUILDING 506A	151	B	5.91	17,899	$1,486	$16,787	$12,616	$1,514	($32)	$14,132	($164)	($1,765)	$1,321	$15,022	1.06	10.70
BUILDING 506A	1	D	0.08	273	$23	$256	$167	$20	($1)	$186	($3)	($27)	$20	$228	1.23	9.26
BUILDING 506A	39	K	2.65	9,267	$769	$8,692	$6,396	$767	($10)	$7,153	$534	$5,740	$1,304	$14,432	2.02	5.49
BUILDING 506B	107	B	4.61	30,638	$2,543	$28,736	$8,940	$1,073	($37)	$9,980	($110)	($1,185)	$2,433	$27,551	2.76	4.10
BUILDING 506B	89	F	10.47	35,226	$2,924	$33,039	$29,169	$3,500	($88)	$32,560	$6,132	$65,854	$9,056	$98,895	3.04	3.60
BUILDING 506B	2	H	0.21	611	$51	$573	$305	$37	($2)	$340	($1)	($7)	$50	$567	1.67	6.78
BUILDING 506B	87	L	15.49	51,587	$4,282	$48,384	$32,451	$3,894	($87)	$36,279	$8,138	$87,399	$12,419	$135,783	3.74	2.92
BUILDING 506C	28	B	1.09	3,957	$328	$3,711	$2,339	$281	($13)	$2,607	($36)	($382)	$293	$3,329	1.28	8.90
BUILDING 506C	28	D	2.18	7,595	$630	$7,124	$4,679	$561	($28)	$5,212	($69)	($743)	$561	$6,381	1.22	9.29
BUILDING 2105 NORTH 1ST FLOOR	115	B	4.49	23,706	$1,968	$22,233	$9,608	$1,153	($55)	$10,706	($174)	($1,867)	$1,794	$20,366	1.90	5.97
BUILDING 2105 NORTH 1ST FLOOR	208	C	11.44	47,376	$3,932	$44,434	$20,960	$2,515	($160)	$23,317	($386)	($4,142)	$3,546	$40,291	1.73	6.57
BUILDING 2105 NORTH 1ST FLOOR	68	H	7.14	28,118	$2,334	$26,372	$10,383	$1,246	($54)	$11,574	($31)	($333)	$2,303	$26,039	2.25	5.03
BUILDING 2105 SOUTH 1ST FLOOR	12	A	0.23	1,601	$133	$1,501	$920	$110	($5)	$1,027	($12)	($132)	$121	$1,370	1.33	8.52
BUILDING 2105 SOUTH 1ST FLOOR	190	B	7.41	31,014	$2,574	$29,088	$15,875	$1,905	($89)	$17,690	($242)	($2,600)	$2,332	$26,488	1.50	7.59
BUILDING 2105 SOUTH 1ST FLOOR	120	C	6.60	24,351	$2,021	$22,839	$12,092	$1,451	($96)	$13,450	($212)	($2,282)	$1,809	$20,557	1.53	7.44
BUILDING 2105 SOUTH 1ST FLOOR	54	H	5.67	20,027	$1,662	$18,784	$8,245	$989	($45)	$9,189	($23)	($246)	$1,639	$18,538	2.02	5.61
BUILDING 2105 SOUTH 2ND FLOOR	461	B	17.98	75,957	$6,304	$71,240	$38,517	$4,622	($208)	$42,936	($591)	($6,352)	$5,713	$64,888	1.51	7.52
BUILDING 2105 SOUTH 2ND FLOOR	28	H	2.94	9,566	$794	$8,972	$4,275	$513	($21)	$4,767	($11)	($115)	$783	$8,857	1.86	6.09
BUILDING 3490	157	B	6.12	18,966	$1,574	$17,788	$13,117	$1,574	($76)	$14,617	($190)	($2,041)	$1,384	$15,747	1.08	10.56
BUILDING 3490	2	C	0.11	366	$30	$343	$202	$24	($2)	$224	($4)	($39)	$27	$304	1.36	8.37
BUILDING 3490	39	H	4.10	13,628	$1,131	$12,782	$5,955	$715	($30)	$6,639	($18)	($191)	$1,113	$12,591	1.90	5.96
Subtotal for SIR > 1.0	**2,180**		**123.6**	**486,584**	**$40,303**	**$455,429**	**$256,449**	**$30,774**	**($1,206)**	**$286,065**	**$12,796**	**$137,425**	**$53,099**	**$592,867**	**2.07**	**5.39**
Lighting Controls Retrofits Recommended																
BUILDING 451	8	J	0.00	3,875	$322	$3,634	$1,041	$125	$0	$1,168	$0	$0	$322	$3,634	3.11	3.63
BUILDING 506A Offices	1	I	0.00	943	$78	$885	$299	$36	$0	$334	$0	$0	$78	$885	2.65	4.27
BUILDING 506B Corridors	21	I	0.00	8,926	$741	$8,372	$6,270	$752	$0	$7,022	$0	$0	$741	$8,372	1.19	9.48
BUILDING 506B Offices	2	I	0.00	1,303	$108	$1,222	$597	$72	$0	$669	$0	$0	$108	$1,222	1.83	6.18
BUILDING 2105 1st Flr N	17	I	0.00	18,352	$1,523	$17,212	$5,075	$609	$0	$5,684	$0	$0	$1,523	$17,212	3.03	3.73
BUILDING 2105 1st Flr N	29	J	0.00	14,540	$1,207	$13,637	$3,775	$453	$0	$4,228	$0	$0	$1,207	$13,637	3.23	3.50
BUILDING 2105 1st Flr S	14	I	0.00	18,315	$1,520	$17,177	$4,180	$502	$0	$4,681	$0	$0	$1,520	$17,177	3.67	3.08
BUILDING 2105 1st Flr S	46	J	0.00	13,619	$1,130	$12,773	$5,988	$719	$0	$6,707	$0	$0	$1,130	$12,773	1.90	5.93
BUILDING 2105 2nd Flr S	32	I	0.00	25,345	$2,104	$23,771	$9,554	$1,146	$0	$10,700	$0	$0	$2,104	$23,771	2.22	5.09
BUILDING 2105 2nd Flr S	45	J	0.00	26,125	$2,168	$24,503	$5,858	$703	$0	$6,561	$0	$0	$2,168	$24,503	3.73	3.03
BUILDING 3482	19	M	0.00	30,680	$2,546	$28,775	$13,589	$1,631	$0	$15,220	$0	$0	$2,546	$28,775	1.89	5.98
BUILDING 3490	6	I	0.00	2,879	$239	$2,700	$1,791	$215	$0	$2,006	$0	$0	$239	$2,700	1.35	8.40
BUILDING 3490	13	J	0.00	3,249	$270	$3,047	$1,692	$203	$0	$1,895	$0	$0	$262	$2,961	1.56	7.23
Subtotal for SIR > 1.0	**253**	**I J M**	**-**	**168,151**	**$13,957**	**$157,709**	**$59,710**	**$7,165**	**$0**	**$66,876**	**$0**	**$0**	**$13,949**	**$157,623**	**2.36**	**4.79**
Total Recommended Lighting & Control Retrofits			**123.6**	**653,735**	**$54,260**	**$613,138**	**$316,158**	**$37,939**	**($1,206)**	**$352,941**	**$12,796**	**$137,425**	**$67,048**	**$750,480**	**2.13**	**5.26**

Revised: October 1994

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TABLE H-1. SUMMARY OF BUILDING LIGHTING AND CONTROLS RETROFIT EVALUATIONS

Building Number	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	(LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC	Economic Meas SIR	Economic Meas Payback
Lighting Retrofits with SIR < 1.0																
BUILDING 451	10	F	0.30	1,099	$91	$1,031	$3,315	$398	($6)	$3,706	$170.6	$1,832	$262	$2,863	0.77	14.15
BUILDING 506B	10	D	0.78	1,840	$153	$1,726	$1,671	$192	($6)	$1,858	($90)	($966)	$63	$760	0.41	29.60
BUILDING 3510	18	G	2.50	1,041	$86	$976	$48,882	$5,621	($9)	$54,495	$23	$250	$110	$1,227	0.02	496.78
BUILDING 2105 NORTH 1ST FLOOR	5	A	0.10	354	$29	$332	$384	$46	($1)	$429	($2)	($26)	$27	$306	0.71	15.92
BUILDING 2105 SOUTH 2ND FLOOR	17	A	0.27	1,284	$107	$1,204	$1,304	$156	($6)	$1,456	($12)	($126)	$95	$1,078	0.74	15.35
BUILDING 2105 SOUTH 2ND FLOOR	6	D	0.33	1,236	$103	$1,159	$1,003	$120	($5)	$1,118	($11)	($117)	$92	$1,042	0.93	12.20
BUILDING 3482	172	G	23.91	62,161	$5,159	$58,301	$467,095	$56,051	($82)	$523,062	$2,096	$22,513	$7,256	$80,814	0.15	72.09
BUILDING 3490	28	A	0.53	1,929	$160	$1,809	$2,148	$258	($8)	$2,399	($17)	($182)	$143	$1,627	0.68	16.76
BUILDING 3510	18	G	2.50	1,041	$86	$976	$48,882	$5,866	($9)	$54,738	$35	$377	$121	$1,353	0.02	450.56
BUILDINGS 451, 506, 2105 & 3490	144	E	2.74	10,806	$897	$10,135	$41,404	$4,969	($44)	$46,326	($80)	($863)	$817	$9,272	0.20	56.74
Lighting Controls Retrofits with SIR < 1.0																
BUILDING 506A Corridors	22	I	0.00	3,847	$319	$3,608	$6,568	$755	$0	$7,323	$0	$0	$319	$3,608	0.49	22.94
BUILDING 506A	101	J	0.00	10,158	$843	$9,527	$13,148	$1,512	$0	$14,645	$0	$0	$843	$9,527	0.65	17.37
BUILDING 506B	181	J	0.00	9,841	$817	$9,230	$23,563	$2,710	$0	$26,245	$0	$0	$817	$9,230	0.35	32.13

LIGHTING RETROFIT LEGEND

A. Retrofit Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp
B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
C. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps
D. Retrofit Unit Cost: 4-Lamp Electronic Ballast & T8 Lamps
E. New Fixture Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp
F. New Fixture Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
G. New Fxtr Unit Cost: 3-Lamp Elect. Bal. & T8 Lamps - Explosion Proof
H. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector
I. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Ceiling Mounted
J. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Automatic Wall Switch
K. New Fixture Unit Cost: 2-Lamp Compact Fluorescent 2 x 13W/5T4
L. New Fxtr Unit Cost: 2-Lamp Elect. Ballast & T8 Lamps, 2' Surface Mount
M. Install Light Switching for Assembly Rooms - Bldg 3482

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

TABLE H-2 BUILDING 451 LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Deman (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	(LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	$ LCC
451	NCO Open Mess	2	10	F	0.30	1,099	$91	$1,031	$3,315	$398	($6)	$3,706	$170.6	$1,832	$262	$2,863
													SIR	0.77	Payback	14.15
451	NCO Open Mess	5	1	B	0.04	139	$12	$130	$84	$10	$0	$94	($1.1)	($11)	$10	$119
451	NCO Open Mess	9	2	B	0.08	236	$20	$221	$167	$20	($1)	$186	($2.1)	($23)	$17	$198
451	NCO Open Mess	15	4	B	0.16	405	$34	$379	$334	$40	($2)	$372	($2.8)	($30)	$31	$349
451	NCO Open Mess	16	2	B	0.08	202	$17	$190	$167	$20	($1)	$186	($1.4)	($15)	$15	$175
451	NCO Open Mess	17	7	B	0.27	1,073	$89	$1,006	$585	$70	($3)	$652	($7.4)	($80)	$82	$926
451	NCO Open Mess	18	8	B	0.31	1,226	$102	$1,150	$668	$80	($4)	$745	($8.5)	($91)	$93	$1,059
451	NCO Open Mess	18	6	B	0.23	919	$76	$862	$501	$60	($3)	$558	($6.4)	($68)	$70	$794
451	NCO Open Mess	19	10	B	0.39	3,065	$254	$2,875	$836	$100	($5)	$931	($21.2)	($228)	$233	$2,647
451	NCO Open Mess	20	10	B	0.39	1,011	$84	$949	$836	$100	($5)	$931	($7.0)	($75)	$77	$874
451	NCO Open Mess	21	10	B	0.39	1,766	$147	$1,657	$836	$100	($5)	$931	($15.9)	($171)	$131	$1,486
451	NCO Open Mess	22	3	B	0.12	530	$44	$497	$251	$30	($1)	$280	($4.8)	($51)	$39	$446
451	NCO Open Mess	23	5	B	0.20	506	$42	$474	$418	$50	($2)	$466	($3.5)	($38)	$38	$437
Totals for Retrofit Type B			68	B	2.65	11,078	$919	$10,390	$5,681	$682	($32)	$6,332	($82)	($880)	$838	$9,510
													SIR	1.50	Payback	7.56
451	NCO Open Mess	10A	1	H	0.08	200	$17	$188	$153	$18	($1)	$170	($1.4)	($15)	$15	$173
451	NCO Open Mess	10B	1	H	0.08	200	$17	$188	$153	$18	($1)	$170	($1.4)	($15)	$15	$173
451	NCO Open Mess	1	1	H	0.08	607	$50	$569	$153	$18	($1)	$170	($4.2)	($46)	$46	$524
451	NCO Open Mess	4	2	H	0.16	550	$46	$516	$305	$37	($2)	$340	($4.2)	($46)	$41	$471
451	NCO Open Mess	5	2	H	0.16	550	$46	$516	$305	$37	($2)	$340	($4.2)	($46)	$41	$471
451	NCO Open Mess	8	3	H	0.23	1,366	$113	$1,281	$458	$55	($3)	$510	($9.5)	($102)	$104	$1,179
451	NCO Open Mess	11	1	H	0.08	200	$17	$188	$153	$18	($1)	$170	($1.4)	($15)	$15	$173
Totals for Retrofit Type H			11	H	0.86	3,675	$305	$3,447	$1,680	$202	($11)	$1,870	($26)	($284)	$279	$3,163
													SIR	1.69	Payback	6.71
451	NCO Open Mess	1	4	K	0.27	2,216	$184	$2,078	$656	$79	($1)	$734	$91.4	$981	$275	$3,060
451	NCO Open Mess	3	1	K	0.07	554	$46	$520	$164	$20	$0	$184	$22.8	$245	$69	$765
451	NCO Open Mess	7	1	K	0.07	554	$46	$520	$164	$20	$0	$184	$22.8	$245	$69	$765
451	NCO Open Mess	9	15	K	0.65	2,067	$172	$1,938	$2,460	$295	($4)	$2,751	$171.3	$1,840	$343	$3,778
451	NCO Open Mess	12	3	K	0.13	413	$34	$388	$492	$59	($1)	$550	$34.3	$368	$69	$756
451	NCO Open Mess	13	8	K	0.22	731	$61	$686	$1,312	$157	($2)	$1,467	$91.4	$981	$152	$1,667
451	NCO Open Mess	13	3	K	0.08	274	$23	$257	$492	$59	($1)	$550	$34.3	$368	$57	$625
Totals for Retrofit Type K			35	K	1.49	6,809	$565	$6,386	$5,740	$689	($9)	$6,420	$468	$5,029	$1,033	$11,415
													SIR	1.78	Payback	6.21
Building Total for SIR > 1.0			**114**	**B H K**	**5.00**	**21,562**	**$1,790**	**$20,223**	**$13,101**	**$1,572**	**($52)**	**$14,622**	**$360**	**$3,865**	**$2,149**	**$24,087**
													SIR	**1.65**	**Payback**	**6.80**

Not Included (nic)

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Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Deman (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
451	NCO Open Mess	4	12	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	6	1	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	13	8	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	14	7	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	14	3	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	14	8	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	24	2	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND
B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
H. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector
K. New Fixture Unit Cost: 2-Lamp Compact Fluorescent 2 x 13W/5T4

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

TABLE H-3 BUILDING 506A LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506A	E M Barracks	307B	8	A	0.19	629	$52	$590	$614	$74	($2)	$685	($5.1)	($55)	$47	$535
506A	E M Barracks	312B	8	A	0.19	629	$52	$590	$614	$74	($2)	$685	($5.1)	($55)	$47	$535
506A	E M Barracks	125	2	A	0.04	367	$30	$344	$153	$18	$0	$172	($2.5)	($27)	$28	$317
506A	E M Barracks	126	2	A	0.04	367	$30	$344	$153	$18	$0	$172	($2.5)	($27)	$28	$317
506A	E M Barracks	127	14	A	0.29	2,568	$213	$2,409	$1,074	$129	($3)	$1,200	($17.8)	($191)	$195	$2,218
506A	E M Barracks	225	2	A	0.04	367	$30	$344	$153	$18	$0	$172	($2.5)	($27)	$28	$317
506A	E M Barracks	234	2	A	0.04	367	$30	$344	$153	$18	$0	$172	($2.5)	($27)	$28	$317
506A	E M Barracks	241	19	A	0.40	3,486	$289	$3,269	$1,457	$175	($4)	$1,628	($24.2)	($259)	$265	$3,010
506A	E M Barracks	325	2	A	0.04	275	$23	$258	$153	$18	$0	$172	($2.5)	($27)	$20	$231
506A	E M Barracks	334	2	A	0.04	275	$23	$258	$153	$18	$0	$172	($2.5)	($27)	$20	$231
506A	E M Barracks	341	19	A	0.40	2,963	$246	$2,779	$1,457	$175	($4)	$1,628	($24.2)	($259)	$222	$2,519
Totals for Retrofit			80	A	1.73	12,293	$1,020	$11,529	$6,136	$736	($15)	$6,858	($92)	($983)	$929	$10,547
													SIR	1.54	Payback	7.38
506A	E M Barracks	129	18	K	1.22	4,277	$355	$4,012	$2,952	$354	($5)	$3,301	$246.7	$2,649	$602	$6,661
506A	E M Barracks	128	21	K	1.43	4,990	$414	$4,680	$3,444	$413	($5)	$3,852	$287.8	$3,091	$702	$7,771
Totals for Retrofit			39	K	2.65	9,267	$769	$8,692	$6,396	$767	($10)	$7,153	$534	$5,740	$1,304	$14,432
													SIR	2.02	Payback	5.49
506A	E M Barracks	305	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	303	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	304	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	314	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	313	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	316	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	315	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	308	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	306	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	311	2	B	0.08	256	$21	$240	$167	$20	($1)	$186	($2.5)	($27)	$19	$212
506A	E M Barracks	310	2	B	0.08	256	$21	$240	$167	$20	($1)	$186	($2.5)	($27)	$19	$212
506A	E M Barracks	232	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	233	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	235	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	229	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	230	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	231	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	236	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	240	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	301	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	302	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	237	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	238	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106

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Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506A	E M Barracks	239	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	317	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	335	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	336	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	337	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	331	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	332	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	333	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	B3	18	B	0.70	1,177	$98	$1,104	$1,504	$180	($9)	$1,675	($11.0)	($118)	$87	$986
506A	E M Barracks	100	8	B	0.31	981	$81	$920	$668	$80	($4)	$745	($7.3)	($79)	$74	$842
506A	E M Barracks	129	2	B	0.08	273	$23	$256	$167	$20	($1)	$186	($2.5)	($27)	$20	$228
506A	E M Barracks	338	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	339	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	340	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	321	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	322	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	323	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	318	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	319	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	320	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	328	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	329	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	330	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	324	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	326	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	327	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	228	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	109	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	110	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	111	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	212A	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	307A	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	312A	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	115	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	116	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	117	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	112	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	113	1	B	0.06	193	$16	$181	$84	$10	$0	$94	($1.3)	($14)	$15	$168
506A	E M Barracks	114	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	207A	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	103	1	B	0.04	123	$10	$115	$84	$10	$0	$94	($0.9)	($10)	$9	$105

TABLE H-3 BUILDING 506A LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	(LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	$ LCC
506A	E M Barracks	104	2	B	0.08	245	$20	$230	$167	$20	($1)	$186	($1.8)	($20)	$19	$210
506A	E M Barracks	107	1	B	0.04	122	$10	$114	$84	$10	$0	$94	($0.9)	($10)	$9	$104
506A	E M Barracks	B2	3	B	0.12	245	$20	$230	$251	$30	($1)	$280	($1.8)	($20)	$19	$210
506A	E M Barracks	101	5	B	0.20	613	$51	$575	$418	$50	($2)	$466	($4.6)	($49)	$46	$526
506A	E M Barracks	102	1	B	0.04	123	$10	$115	$84	$10	$0	$94	($0.9)	($10)	$9	$105
506A	E M Barracks	124	6	B	0.23	736	$61	$690	$501	$60	($3)	$558	($5.5)	($59)	$56	$631
506A	E M Barracks	106	2	B	0.08	225	$19	$211	$167	$20	($1)	$186	($1.7)	($18)	$17	$193
506A	E M Barracks	108A	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	121	2	B	0.08	245	$20	$230	$167	$20	($1)	$186	($1.8)	($20)	$19	$210
506A	E M Barracks	122	6	B	0.23	736	$61	$690	$501	$60	($3)	$558	($5.5)	($59)	$56	$631
506A	E M Barracks	123	4	B	0.16	491	$41	$460	$334	$40	($2)	$372	($3.7)	($39)	$37	$421
506A	E M Barracks	217	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	218	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	219	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	214	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	215	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	216	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	224	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	226	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	227	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	220	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	221	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	223	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	213	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	118	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	202	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	203	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	120	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	119	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	201	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	208	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	210	2	B	0.08	256	$21	$240	$167	$20	($1)	$186	($2.5)	($27)	$19	$212
506A	E M Barracks	211	2	B	0.08	256	$21	$240	$167	$20	($1)	$186	($2.5)	($27)	$19	$212
506A	E M Barracks	205	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	204	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506A	E M Barracks	206	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
Totals for Retrofit			151	B	5.91	17,899	$1,486	$16,787	$12,616	$1,514	($32)	$14,132	($164)	($1,765)	$1,321	$15,022
													SIR	1.06	Payback	10.70
506A	E M Barracks	128	1	D	0.08	273	$23	$256	$167	$20	($1)	$186	($2.5)	($27)	$20	$228
Totals for Retrofit			1	D	0.08	273	$23	$256	$167	$20	($1)	$186	($3)	($27)	$20	$228
													SIR	1.23	Payback	9.26

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TABLE H-3 BUILDING 506A LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
Building Total for SIR > 1.0			271	A B D K	10.37	39,731	$3,298	$37,264	$25,315	$3,038	($58)	$28,329	$276	$2,965	$3,574	$40,229
													SIR	1.42	Payback	7.93
506A	E M Barracks	108C	2	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	100	4	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	B1	LOCKED	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	212C	2	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	207C	2	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	105	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	309	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	128	7	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	209	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	312C	2	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	307C	2	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND
A. Retrofit Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp
B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
D. Retrofit Unit Cost: 4-Lamp Electronic Ballast & T8 Lamps
K. New Fixture Unit Cost: 2-Lamp Compact Fluorescent 2 x 13W/5T4

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

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TABLE H-4 BUILDING 506B LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks	130	1	B	0.18	583	$48	$547	$84	$10	($1)	$93	$94.3	$1,013	$143	$1,559
506B	E M Barracks	131	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
506B	E M Barracks	132	1	B	0.14	1,214	$101	$1,139	$84	$10	($1)	$93	$3.2	$34	$104	$1,173
506B	E M Barracks	132	18	B	0.70	6,133	$509	$5,752	$1,504	$180	($6)	$1,678	($45.8)	($491)	$463	$5,260
506B	E M Barracks	134	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
506B	E M Barracks	135	8	B	0.31	1,533	$127	$1,438	$668	$80	($3)	$746	($15.3)	($164)	$112	$1,274
506B	E M Barracks	136	4	B	0.16	109	$9	$102	$334	$40	($1)	$373	($1.0)	($11)	$8	$91
506B	E M Barracks	137	3	B	0.12	1,022	$85	$959	$251	$30	($1)	$280	($7.6)	($82)	$77	$877
506B	E M Barracks	141	1	B	0.04	27	$2	$26	$84	$10	$0	$94	($0.3)	($3)	$2	$23
506B	E M Barracks	142	2	B	0.08	55	$5	$51	$167	$20	($1)	$186	($0.5)	($5)	$4	$46
506B	E M Barracks	143	1	B	0.14	455	$38	$427	$84	$10	($1)	$93	$1.6	$17	$39	$444
506B	E M Barracks	144	1	B	0.04	128	$11	$120	$84	$10	$0	$94	($1.3)	($14)	$9	$106
506B	E M Barracks	145	1	B	0.04	27	$2	$26	$84	$10	$0	$94	($0.3)	($3)	$2	$23
506B	E M Barracks	146	10	B	0.39	920	$76	$863	$836	$100	($3)	$933	($9.2)	($98)	$67	$764
506B	E M Barracks	230	3	B	0.12	575	$48	$539	$251	$30	($1)	$280	($5.7)	($61)	$42	$478
506B	E M Barracks	231	1	B	0.04	27	$2	$26	$84	$10	$0	$94	($0.3)	($3)	$2	$23
506B	E M Barracks	232	3	B	0.12	1,022	$85	$959	$251	$30	($1)	$280	($7.6)	($82)	$77	$877
506B	E M Barracks	235	16	B	0.62	5,451	$452	$5,113	$1,337	$160	($5)	$1,492	($40.7)	($437)	$412	$4,676
506B	E M Barracks	236	1	B	0.14	1,214	$101	$1,139	$84	$10	($1)	$93	$3.2	$34	$104	$1,173
506B	E M Barracks	236	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
506B	E M Barracks	330	3	B	0.12	575	$48	$539	$251	$30	($1)	$280	($5.7)	($61)	$42	$478
506B	E M Barracks	331	1	B	0.04	27	$2	$26	$84	$10	$0	$94	($0.3)	($3)	$2	$23
506B	E M Barracks	332	3	B	0.12	1,022	$85	$959	$251	$30	($1)	$280	($7.6)	($82)	$77	$877
506B	E M Barracks	335	16	B	0.62	5,451	$452	$5,113	$1,337	$160	($5)	$1,492	($40.7)	($437)	$412	$4,676
506B	E M Barracks	336	3	B	0.12	1,022	$85	$959	$251	$30	($1)	$280	($7.6)	($82)	$77	$877
Totals for Retrofit Type B			107	B	4.61	30,638	$2,543	$28,736	$8,940	$1,073	($37)	$9,980	($110)	($1,185)	$2,433	$27,551
													SIR	2.76	Payback	4.10
506B	E M Barracks	138	8	D	0.62	1,472	$122	$1,380	$1,337	$160	($5)	$1,492	($14.6)	($157)	$108	$1,223
506B	E M Barracks	139	2	D	0.16	368	$31	$345	$334	$40	($1)	$373	($3.7)	($39)	$27	$306
Totals for Retrofit Type D			10	D	0.78	1,840	$153	$1,726	$1,671	$201	($6)	$1,865	($18)	($197)	$134	$1,529
													SIR	0.82	Payback	13.88
506B	E M Barracks	101	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	102	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	103	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	104	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	105	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	106	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	107	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	108	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	109	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114

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TABLE H-4 BUILDING 506B LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks	110	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	111	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	112	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	113	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	114	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	115	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	116	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	117	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	118	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	119	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	120	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	121	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	122	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	123	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	124	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	125	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	126	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	127	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	128	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	129	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	130	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	143	1	F	(0.00)	(3)	($0)	($3)	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	201	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	202	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	203	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	204	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	205	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	206	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	207	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	208	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	209	1	F	0.12	403	$33	$378	$331	$40	($1)	$370	$69.7	$748	$103	$1,127
506B	E M Barracks	210	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	211	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	212	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	213	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	214	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	215	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	216	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	217	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	218	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	219	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	220	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114

TABLE H-4 BUILDING 506B LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks	221	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	222	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	223	1	F	0.12	390	$32	$366	$331	$40	($1)	$370	$69.7	$748	$102	$1,114
506B	E M Barracks	224	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	225	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	226	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	227	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	228	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	229	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	301	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	302	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	303	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	304	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	305	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	306	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	307	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	308	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	309	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	310	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	311	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	312	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	313	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	314	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	315	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	316	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	317	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	318	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	319	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	320	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	321	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	322	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	323	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	324	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	325	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	326	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	327	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	328	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
506B	E M Barracks	329	1	F	0.12	416	$35	$390	$331	$40	($1)	$370	$69.7	$748	$104	$1,138
Totals for Retrofit Type F			89	F	10.47	35,226	$2,924	$33,039	$29,169	$3,500	($88)	$32,560	$6,132	$65,854	$9,056	$98,895
													SIR	3.04	Payback	3.60
506B	E M Barracks	100	2	H	0.21	611	$51	$573	$305	$37	($2)	$340	($0.6)	($7)	$50	$567

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TABLE H-4 BUILDING 506B LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
Totals for Retrofit Type H			2	H	0.21	611	$51	$573	$305	$37	($2)	$340	($1)	($7)	$50	$567
													SIR	1.67	Payback	6.78
506B	E M Barracks	101	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	102	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	103	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	104	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	105	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	106	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	107	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	108	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	109	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	110	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	111	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	112	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	113	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	114	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	115	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	116	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	117	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	118	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	119	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	120	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	121	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	122	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	123	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	124	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	125	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	126	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	127	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	128	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	129	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	201	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	202	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	203	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	204	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	205	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	206	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	207	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	208	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	209	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	210	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588

TABLE H-4 BUILDING 506B LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks	211	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	212	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	213	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	214	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	215	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	216	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	217	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	218	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	219	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	220	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	221	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	222	1	L	0.18	622	$52	$583	$373	$45	($1)	$417	$93.5	$1,005	$145	$1,588
506B	E M Barracks	223	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	224	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	225	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	226	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	227	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	228	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	229	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	301	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	302	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	303	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	304	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	305	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	306	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	307	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	308	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	309	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	310	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	311	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	312	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	313	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	314	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	315	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	316	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	317	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	318	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	319	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	320	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	321	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	322	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	323	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551

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Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks	324	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	325	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	326	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	327	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	328	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
506B	E M Barracks	329	1	L	0.18	583	$48	$547	$373	$45	($1)	$417	$93.5	$1,005	$142	$1,551
Totals for Retrofit Type L			87	L	15.49	51,587	$4,282	$48,384	$32,451	$3,894	($87)	$36,279	$8,138	$87,399	$12,419	$135,783
													SIR	3.74	Payback	2.92
Project Total for SIR > 1			**285**	**B F H L**	**30.78**	**118,063**	**$9,799**	**$110,732**	**$70,866**	**$8,504**	**($214)**	**$79,159**	**$14,158**	**$152,061**	**$23,958**	**$262,795**
													SIR	**3.32**	**Payback**	**3.30**
506B	E M Barracks	200	LOCKED	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	338	NO LTS	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	333	NO LTS	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	238	NO LTS	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	300	NO LTS	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	233	NO LTS	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	337	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	133	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	234	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	334	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	237	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	140	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND
B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
D. Retrofit Unit Cost: 4-Lamp Electronic Ballast & T8 Lamps
F. New Fixture Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
H. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector
L. New Fxtr Unit Cost: 2-Lamp Elect. Ballast & T8 Lamps, 2' Surface Mount

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

TABLE H-5 BUILDING 506C LIGHTING RETROFIT EVALUATIONS

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506C	E M Barracks	2	5	B	0.20	707	$59	$663	$418	$50	($2)	$466	($6.4)	($68)	$52	$594
506C	E M Barracks	3	4	B	0.16	565	$47	$530	$334	$40	($2)	$372	($5.1)	($55)	$42	$476
506C	E M Barracks	5	19	B	0.74	2,685	$223	$2,518	$1,587	$190	($9)	$1,769	($24.2)	($259)	$199	$2,259
Totals for Retrofit			28	B	1.09	3,957	$328	$3,711	$2,339	$281	($13)	$2,607	($36)	($382)	$293	$3,329
													SIR	1.28	Payback	8.90
506C	E M Barracks	1	24	D	1.87	6,699	$556	$6,283	$4,010	$481	($24)	$4,468	($61.0)	($655)	$495	$5,628
506C	E M Barracks	4	1	D	0.08	59	$5	$56	$167	$20	($1)	$186	($0.5)	($5)	$4	$50
506C	E M Barracks	5	3	D	0.23	837	$69	$785	$501	$60	($3)	$558	($7.6)	($82)	$62	$703
Totals for Retrofit Type D			28	D	2.18	7,595	$630	$7,124	$4,679	$561	($28)	$5,212	($69)	($743)	$561	$6,381
													SIR	1.22	Payback	9.29
506C	E M Barracks	1	8	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
Building Total for SIR > 1.0			**56**	**B & D**	**3.28**	**11,552**	**$959**	**$10,835**	**$7,018**	**$842**	**($41)**	**$7,819**	**($105)**	**($1,125)**	**$854**	**$9,710**
													SIR	**1.24**	**Payback**	**9.16**

LIGHTING RETROFIT LEGEND B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
D. Retrofit Unit Cost: 4-Lamp Electronic Ballast & T8 Lamps

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

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TABLE H-6 BUILDING 2105 NORTHSIDE FIRST FLOOR LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	37	2	A	0.04	109	$9	$102	$153	$18	($1)	$171	($0.8)	($8)	$8	$94
2105	Range Opert Cent	38	1	A	0.02	54	$5	$51	$77	$9	$0	$86	($0.4)	($4)	$4	$47
2105	Range Opert Cent	41	1	A	0.02	9	$1	$8	$77	$9	$0	$86	($0.1)	($1)	$1	$8
2105	Range Opert Cent	44	1	A	0.02	183	$15	$171	$77	$9	$0	$86	($1.3)	($14)	$14	$158
Totals for Retrofit Type A			5	A	0.10	354	$29	$332	$384	$46	($1)	$429	($2)	($26)	$27	$306
													SIR	0.71	Payback	15.92
2105	Range Opert Cent	1	2	B	0.08	736	$61	$690	$167	$20	($1)	$186	($5.1)	($55)	$56	$635
2105	Range Opert Cent	20	4	B	0.16	1,471	$122	$1,380	$334	$40	($2)	$372	($10.2)	($109)	$112	$1,271
2105	Range Opert Cent	22	4	B	0.16	1,471	$122	$1,380	$334	$40	($2)	$372	($10.2)	($109)	$112	$1,271
2105	Range Opert Cent	23	6	B	0.23	953	$79	$894	$501	$60	($3)	$558	($7.3)	($78)	$72	$816
2105	Range Opert Cent	24	7	B	0.27	1,112	$92	$1,043	$585	$70	($3)	$652	($8.5)	($91)	$84	$952
2105	Range Opert Cent	25	4	B	0.16	1,471	$122	$1,380	$334	$40	($2)	$372	($10.2)	($109)	$112	$1,271
2105	Range Opert Cent	26	2	B	0.08	736	$61	$690	$167	$20	($1)	$186	($5.1)	($55)	$56	$635
2105	Range Opert Cent	27	7	B	0.27	2,574	$214	$2,415	$585	$70	($3)	$652	($17.8)	($191)	$196	$2,224
2105	Range Opert Cent	30	6	B	0.23	953	$79	$894	$501	$60	($3)	$558	($7.3)	($78)	$72	$816
2105	Range Opert Cent	31	8	B	0.31	1,271	$106	$1,192	$668	$80	($4)	$745	($9.7)	($104)	$96	$1,088
2105	Range Opert Cent	32	10	B	0.39	1,589	$132	$1,490	$836	$100	($5)	$931	($12.1)	($130)	$120	$1,360
2105	Range Opert Cent	33	10	B	0.39	1,589	$132	$1,490	$836	$100	($5)	$931	($12.1)	($130)	$120	$1,360
2105	Range Opert Cent	34	10	B	0.39	1,589	$132	$1,490	$836	$100	($5)	$931	($12.1)	($130)	$120	$1,360
2105	Range Opert Cent	35	3	B	0.12	477	$40	$447	$251	$30	($1)	$280	($3.6)	($39)	$36	$408
2105	Range Opert Cent	36	5	B	0.20	795	$66	$745	$418	$50	($2)	$466	($6.1)	($65)	$60	$680
2105	Range Opert Cent	44	3	B	0.12	1,103	$92	$1,035	$251	$30	($1)	$280	($7.6)	($82)	$84	$953
2105	Range Opert Cent	53	2	B	0.08	318	$26	$298	$167	$20	($1)	$186	($2.4)	($26)	$24	$272
2105	Range Opert Cent	63	10	B	0.39	1,589	$132	$1,490	$836	$100	($5)	$931	($12.1)	($130)	$120	$1,360
2105	Range Opert Cent	9	12	B	0.47	1,907	$158	$1,789	$1,003	$120	($6)	$1,117	($14.5)	($156)	$144	$1,633
Totals for Retrofit Type B			115	B	4.49	23,706	$1,968	$22,233	$9,608	$1,153	($55)	$10,706	($174)	($1,867)	$1,794	$20,366
													SIR	1.90	Payback	5.97
2105	Range Opert Cent	10	6	C	0.33	1,333	$111	$1,250	$605	$73	($5)	$672	($10.9)	($117)	$100	$1,133
2105	Range Opert Cent	11	8	C	0.44	1,777	$148	$1,667	$806	$97	($6)	$897	($14.5)	($156)	$133	$1,511
2105	Range Opert Cent	12	2	C	0.11	444	$37	$417	$202	$24	($2)	$224	($3.6)	($39)	$33	$378
2105	Range Opert Cent	13	2	C	0.11	444	$37	$417	$202	$24	($2)	$224	($3.6)	($39)	$33	$378
2105	Range Opert Cent	14	2	C	0.11	444	$37	$417	$202	$24	($2)	$224	($3.6)	($39)	$33	$378
2105	Range Opert Cent	15,16	13	C	0.71	2,888	$240	$2,709	$1,310	$157	($10)	$1,457	($23.6)	($254)	$216	$2,455
2105	Range Opert Cent	17	8	C	0.44	1,777	$148	$1,667	$806	$97	($6)	$897	($14.5)	($156)	$133	$1,511
2105	Range Opert Cent	19	3	C	0.17	666	$55	$625	$302	$36	($2)	$337	($5.4)	($59)	$50	$567
2105	Range Opert Cent	3,5,7	21	C	1.16	4,665	$387	$4,375	$2,116	$254	($16)	$2,354	($38.1)	($410)	$349	$3,966
2105	Range Opert Cent	4	60	C	3.30	13,329	$1,106	$12,501	$6,046	$726	($46)	$6,726	($109.0)	($1,170)	$997	$11,331

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TABLE H-6 BUILDING 2105 NORTHSIDE FIRST FLOOR LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	40	4	C	0.22	2,058	$171	$1,930	$403	$48	($3)	$448	($15.3)	($164)	$156	$1,767
2105	Range Opert Cent	46	4	C	0.22	889	$74	$833	$403	$48	($3)	$448	($7.3)	($78)	$66	$755
2105	Range Opert Cent	48	8	C	0.44	1,777	$148	$1,667	$806	$97	($6)	$897	($14.5)	($156)	$133	$1,511
2105	Range Opert Cent	52	25	C	1.38	5,554	$461	$5,209	$2,519	$302	($19)	$2,803	($45.4)	($488)	$416	$4,721
2105	Range Opert Cent	59	22	C	1.21	4,887	$406	$4,584	$2,217	$266	($17)	$2,466	($39.9)	($429)	$366	$4,155
2105	Range Opert Cent	6	6	C	0.33	1,333	$111	$1,250	$605	$73	($5)	$672	($10.9)	($117)	$100	$1,133
2105	Range Opert Cent	60	8	C	0.44	1,777	$148	$1,667	$806	$97	($6)	$897	($14.5)	($156)	$133	$1,511
2105	Range Opert Cent	61	3	C	0.17	666	$55	$625	$302	$36	($2)	$337	($5.4)	($59)	$50	$567
2105	Range Opert Cent	62	3	C	0.17	666	$55	$625	$302	$36	($2)	$337	($5.4)	($59)	$50	$567
Totals for Retrofit Type C			208	C	11.44	47,376	$3,932	$44,434	$20,960	$2,515	($160)	$23,317	($386)	($4,142)	$3,546	$40,291
													SIR	1.73	Payback	6.57
2105	Range Opert Cent	18	2	H	0.21	827	$69	$776	$305	$37	($2)	$340	($0.9)	($10)	$68	$766
2105	Range Opert Cent	2	8	H	0.84	3,308	$275	$3,103	$1,222	$147	($6)	$1,362	($3.6)	($39)	$271	$3,063
2105	Range Opert Cent	2A	8	H	0.84	3,308	$275	$3,103	$1,222	$147	($6)	$1,362	($3.6)	($39)	$271	$3,063
2105	Range Opert Cent	3A	4	H	0.42	1,654	$137	$1,551	$611	$73	($3)	$681	($1.8)	($20)	$135	$1,532
2105	Range Opert Cent	45	16	H	1.68	6,616	$549	$6,205	$2,443	$293	($12)	$2,724	($7.3)	($78)	$542	$6,127
2105	Range Opert Cent	47	2	H	0.21	827	$69	$776	$305	$37	($2)	$340	($0.9)	($10)	$68	$766
2105	Range Opert Cent	50	16	H	1.68	6,616	$549	$6,205	$2,443	$293	($12)	$2,724	($7.3)	($78)	$542	$6,127
2105	Range Opert Cent	54	2	H	0.21	827	$69	$776	$305	$37	($2)	$340	($0.9)	($10)	$68	$766
2105	Range Opert Cent	55	2	H	0.21	827	$69	$776	$305	$37	($2)	$340	($0.9)	($10)	$68	$766
2105	Range Opert Cent	56	2	H	0.21	827	$69	$776	$305	$37	($2)	$340	($0.9)	($10)	$68	$766
2105	Range Opert Cent	8	6	H	0.63	2,481	$206	$2,327	$916	$110	($5)	$1,021	($2.7)	($29)	$203	$2,298
Totals for Retrofit Type H			68	H	7.14	28,118	$2,334	$26,372	$10,383	$1,246	($54)	$11,574	($31)	($333)	$2,303	$26,039
													SIR	2.25	Payback	5.03
Building Total for SIR > 1.0			**391**	**B C H**	**23.07**	**99,199**	**$8,234**	**$93,039**	**$40,951**	**$4,914**	**($269)**	**$45,597**	**($591)**	**($6,342)**	**$7,643**	**$86,697**
													SIR	**1.90**	**Payback**	**5.97**
2105	Range Opert Cent	21	8	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	58A	27	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	58	10	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	44	3	-	0.00	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND
A. Retrofit Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp
B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
C. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps
H. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

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TABLE H-7 BUILDING 2105 SOUTHSIDE FIRST FLOOR LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	136B	2	A	0.04	332	$28	$311	$153	$18	($1)	$171	($2.5)	($27)	$25	$284
2105	Range Opert Cent	139B	2	A	0.04	332	$28	$311	$153	$18	($1)	$171	($2.5)	($27)	$25	$284
2105	Range Opert Cent	65	2	A	0.04	332	$28	$311	$153	$18	($1)	$171	($2.5)	($27)	$25	$284
2105	Range Opert Cent	67	2	A	0.04	99	$8	$93	$153	$18	($1)	$171	($0.8)	($8)	$7	$85
2105	Range Opert Cent	82	1	A	0.02	166	$14	$156	$77	$9	$0	$86	($1.3)	($14)	$13	$142
2105	Range Opert Cent	137	1	A	0.02	8	$1	$7	$77	$9	$0	$86	($0.1)	($1)	$1	$7
2105	Range Opert Cent	146	2	A	0.04	332	$28	$311	$153	$18	($1)	$171	($2.5)	($27)	$25	$284
Totals for Retrofit			12	A	0.23	1,601	$133	$1,501	$920	$110	($5)	$1,027	($12)	($132)	$121	$1,370
													SIR	1.33	Payback	8.52
2105	Range Opert Cent	105A	14	B	0.55	1,420	$118	$1,331	$1,170	$140	($7)	$1,303	($10.6)	($114)	$107	$1,218
2105	Range Opert Cent	105B	2	B	0.08	292	$24	$274	$167	$20	($1)	$186	($2.4)	($26)	$22	$248
2105	Range Opert Cent	108A	26	B	1.01	2,636	$219	$2,473	$2,172	$261	($13)	$2,420	($19.7)	($211)	$199	$2,261
2105	Range Opert Cent	108B	9	B	0.35	913	$76	$856	$752	$90	($4)	$838	($6.8)	($73)	$69	$783
2105	Range Opert Cent	119B	7	B	0.27	1,022	$85	$959	$585	$70	($3)	$652	($8.5)	($91)	$76	$868
2105	Range Opert Cent	122A	17	B	0.66	1,724	$143	$1,617	$1,420	$170	($8)	$1,583	($12.9)	($138)	$130	$1,479
2105	Range Opert Cent	136A	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
2105	Range Opert Cent	139A	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
2105	Range Opert Cent	83B	2	B	0.08	203	$17	$190	$167	$20	($1)	$186	($1.5)	($16)	$15	$174
2105	Range Opert Cent	85A	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
2105	Range Opert Cent	85B	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
2105	Range Opert Cent	66	5	B	0.20	1,704	$141	$1,598	$418	$50	($2)	$466	($12.7)	($137)	$129	$1,461
2105	Range Opert Cent	68	3	B	0.12	1,022	$85	$959	$251	$30	($1)	$280	($7.6)	($82)	$77	$877
2105	Range Opert Cent	69	8	B	0.31	1,168	$97	$1,096	$668	$80	($4)	$745	($9.7)	($104)	$87	$992
2105	Range Opert Cent	74	33	B	1.29	4,819	$400	$4,519	$2,757	$331	($16)	$3,072	($39.9)	($429)	$360	$4,090
2105	Range Opert Cent	88	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	92	2	B	0.08	152	$13	$143	$167	$20	($1)	$186	($1.5)	($16)	$11	$126
2105	Range Opert Cent	95	4	B	0.16	584	$48	$548	$334	$40	($2)	$372	($4.8)	($52)	$44	$496
2105	Range Opert Cent	96	4	B	0.16	584	$48	$548	$334	$40	($2)	$372	($4.8)	($52)	$44	$496
2105	Range Opert Cent	97	4	B	0.16	584	$48	$548	$334	$40	($2)	$372	($4.8)	($52)	$44	$496
2105	Range Opert Cent	102	4	B	0.16	584	$48	$548	$334	$40	($2)	$372	($4.8)	($52)	$44	$496
2105	Range Opert Cent	103	4	B	0.16	584	$48	$548	$334	$40	($2)	$372	($4.8)	($52)	$44	$496
2105	Range Opert Cent	106	4	B	0.16	406	$34	$380	$334	$40	($2)	$372	($3.0)	($33)	$31	$348
2105	Range Opert Cent	109	1	B	0.04	51	$4	$48	$84	$10	$0	$94	($0.8)	($8)	$3	$39
2105	Range Opert Cent	110	1	B	0.04	51	$4	$48	$84	$10	$0	$94	($0.8)	($8)	$3	$39
2105	Range Opert Cent	111	2	B	0.08	292	$24	$274	$167	$20	($1)	$186	($2.4)	($26)	$22	$248
2105	Range Opert Cent	125	2	B	0.08	292	$24	$274	$167	$20	($1)	$186	($2.4)	($26)	$22	$248
2105	Range Opert Cent	126	2	B	0.08	292	$24	$274	$167	$20	($1)	$186	($2.4)	($26)	$22	$248
2105	Range Opert Cent	130	5	B	0.20	1,704	$141	$1,598	$418	$50	($2)	$466	($12.7)	($137)	$129	$1,461
2105	Range Opert Cent	132	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
2105	Range Opert Cent	133	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
2105	Range Opert Cent	138	1	B	0.04	341	$28	$320	$84	$10	$0	$94	($2.5)	($27)	$26	$292

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TABLE H-7 BUILDING 2105 SOUTHSIDE FIRST FLOOR LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	140	8	B	0.31	2,726	$226	$2,556	$668	$80	($4)	$745	($20.3)	($218)	$206	$2,338
2105	Range Opert Cent	145	1	B	0.04	341	$28	$320	$84	$10	$0	$94	($2.5)	($27)	$26	$292
Totals for Retrofit			190	B	7.41	31,014	$2,574	$29,088	$15,875	$1,905	($89)	$17,690	($242)	($2,600)	$2,332	$26,488
													SIR	1.50	Payback	7.59
2105	Range Opert Cent	117A	3	C	0.17	618	$51	$579	$302	$36	($2)	$337	($5.4)	($59)	$46	$521
2105	Range Opert Cent	117B	1	C	0.06	206	$17	$193	$101	$12	($1)	$112	($1.8)	($20)	$15	$174
2105	Range Opert Cent	117C	1	C	0.06	206	$17	$193	$101	$12	($1)	$112	($1.8)	($20)	$15	$174
2105	Range Opert Cent	79A	2	C	0.11	412	$34	$386	$202	$24	($2)	$224	($3.6)	($39)	$31	$347
2105	Range Opert Cent	79B	2	C	0.11	412	$34	$386	$202	$24	($2)	$224	($3.6)	($39)	$31	$347
2105	Range Opert Cent	85C	4	C	0.22	824	$68	$773	$403	$48	($3)	$448	($7.3)	($78)	$61	$695
2105	Range Opert Cent	87A	8	C	0.44	183	$15	$172	$806	$97	($6)	$897	($1.5)	($16)	$14	$156
2105	Range Opert Cent	87C	2	C	0.11	412	$34	$386	$202	$24	($2)	$224	($3.6)	($39)	$31	$347
2105	Range Opert Cent	90A	15	C	0.83	1,716	$142	$1,609	$1,512	$181	($12)	$1,681	($17.0)	($183)	$125	$1,427
2105	Range Opert Cent	91A	7	C	0.39	751	$62	$704	$705	$85	($5)	$785	($7.9)	($85)	$54	$619
2105	Range Opert Cent	94A	2	C	0.11	286	$24	$268	$202	$24	($2)	$224	($2.3)	($24)	$21	$244
2105	Range Opert Cent	94B	4	C	0.22	824	$68	$773	$403	$48	($3)	$448	($7.3)	($78)	$61	$695
2105	Range Opert Cent	72	8	C	0.44	1,647	$137	$1,545	$806	$97	($6)	$897	($14.5)	($156)	$122	$1,389
2105	Range Opert Cent	73	4	C	0.22	824	$68	$773	$403	$48	($3)	$448	($7.3)	($78)	$61	$695
2105	Range Opert Cent	75	2	C	0.11	412	$34	$386	$202	$24	($2)	$224	($3.6)	($39)	$31	$347
2105	Range Opert Cent	76	3	C	0.17	618	$51	$579	$302	$36	($2)	$337	($5.4)	($59)	$46	$521
2105	Range Opert Cent	77	3	C	0.17	618	$51	$579	$302	$36	($2)	$337	($5.4)	($59)	$46	$521
2105	Range Opert Cent	78	4	C	0.22	1,922	$160	$1,803	$403	$48	($3)	$448	($15.3)	($164)	$144	$1,639
2105	Range Opert Cent	80	2	C	0.11	412	$34	$386	$202	$24	($2)	$224	($3.6)	($39)	$31	$347
2105	Range Opert Cent	81	2	C	0.11	412	$34	$386	$202	$24	($2)	$224	($3.6)	($39)	$31	$347
2105	Range Opert Cent	84	4	C	0.22	1,922	$160	$1,803	$403	$48	($3)	$448	($15.3)	($164)	$144	$1,639
2105	Range Opert Cent	86	2	C	0.11	412	$34	$386	$202	$24	($2)	$224	($3.6)	($39)	$31	$347
2105	Range Opert Cent	98	1	C	0.06	480	$40	$451	$101	$12	($1)	$112	($3.8)	($41)	$36	$410
2105	Range Opert Cent	101	9	C	0.50	1,853	$154	$1,738	$907	$109	($7)	$1,009	($16.3)	($176)	$137	$1,563
2105	Range Opert Cent	104	4	C	0.22	824	$68	$773	$403	$48	($3)	$448	($7.3)	($78)	$61	$695
2105	Range Opert Cent	112	5	C	0.28	1,030	$85	$966	$504	$60	($4)	$560	($9.1)	($98)	$76	$868
2105	Range Opert Cent	113	2	C	0.11	412	$34	$386	$202	$24	($2)	$224	($3.6)	($39)	$31	$347
2105	Range Opert Cent	116	2	C	0.11	412	$34	$386	$202	$24	($2)	$224	($3.6)	($39)	$31	$347
2105	Range Opert Cent	118	3	C	0.17	618	$51	$579	$302	$36	($2)	$337	($5.4)	($59)	$46	$521
2105	Range Opert Cent	121	2	C	0.11	412	$34	$386	$202	$24	($2)	$224	($3.6)	($39)	$31	$347
2105	Range Opert Cent	127	4	C	0.22	824	$68	$773	$403	$48	($3)	$448	($7.3)	($78)	$61	$695
2105	Range Opert Cent	142	3	C	0.17	1,441	$120	$1,352	$302	$36	($2)	$337	($11.4)	($123)	$108	$1,229
Totals for Retrofit			120	C	6.60	24,351	$2,021	$22,839	$12,092	$1,451	($96)	$13,450	($212)	($2,282)	$1,809	$20,557
													SIR	1.53	Payback	7.44
2105	Range Opert Cent	119A	2	H	0.21	786	$65	$737	$305	$37	($2)	$340	($0.9)	($10)	$64	$728
2105	Range Opert Cent	120B	5	H	0.53	1,365	$113	$1,280	$763	$92	($4)	$851	($1.4)	($15)	$112	$1,265

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TABLE H-7 BUILDING 2105 SOUTHSIDE FIRST FLOOR LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	122B	3	H	0.32	819	$68	$768	$458	$55	($2)	$511	($0.9)	($9)	$67	$759
2105	Range Opert Cent	70	2	H	0.21	786	$65	$737	$305	$37	($2)	$340	($0.9)	($10)	$64	$728
2105	Range Opert Cent	71	2	H	0.21	786	$65	$737	$305	$37	($2)	$340	($0.9)	($10)	$64	$728
2105	Range Opert Cent	93	2	H	0.21	546	$45	$512	$305	$37	($2)	$340	($0.6)	($6)	$45	$506
2105	Range Opert Cent	99	2	H	0.21	786	$65	$737	$305	$37	($2)	$340	($0.9)	($10)	$64	$728
2105	Range Opert Cent	100	28	H	2.94	11,007	$914	$10,324	$4,275	$513	($22)	$4,766	($12.8)	($137)	$901	$10,187
2105	Range Opert Cent	114	2	H	0.21	786	$65	$737	$305	$37	($2)	$340	($0.9)	($10)	$64	$728
2105	Range Opert Cent	115	2	H	0.21	786	$65	$737	$305	$37	($2)	$340	($0.9)	($10)	$64	$728
2105	Range Opert Cent	128	4	H	0.42	1,572	$131	$1,475	$611	$73	($3)	$681	($1.8)	($20)	$129	$1,455
Totals for Retrofit			54	H	5.67	20,027	$1,662	$18,784	$8,245	$989	($45)	$9,189	($23)	($246)	$1,639	$18,538
													SIR	2.02	Payback	5.61
Totals for SIR > 1			**376**	**A B C H**	**19.91**	**76,994**	**$6,390**	**$72,212**	**$37,133**	**$4,456**	**($235)**	**$41,356**	**($490)**	**($5,260)**	**$5,901**	**$66,953**
													SIR	**1.62**	**Payback**	**7.01**
Not included (nic)																
2105	Range Opert Cent	120A	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	83A	17	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	86A	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	87B	7	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	91B	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	91C	8	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	83	6	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	89	9	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	124	3	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	131	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	134	2	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	141	4	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND
A. Retrofit Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp
B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
C. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps
H. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

TABLE H-8 BUILDING 2105 SOUTHSIDE SECOND FLOOR LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	234B	2	A	0.04	332	$28	$311	$153	$18	($1)	$171	($2.5)	($27)	$25	$284
2105	Range Opert Cent	236B	2	A	0.04	332	$28	$311	$153	$18	($1)	$171	($2.5)	($27)	$25	$284
2105	Range Opert Cent	150	1	A	0.02	166	$14	$156	$77	$9	$0	$86	($1.3)	($14)	$13	$142
2105	Range Opert Cent	152	2	A	0.04	99	$8	$93	$153	$18	($1)	$171	($0.8)	($8)	$7	$85
2105	Range Opert Cent	153	2	A	0.04	99	$8	$93	$153	$18	($1)	$171	($0.8)	($8)	$7	$85
2105	Range Opert Cent	214	5	A	0.04	150	$12	$140	$384	$46	($2)	$428	($3.0)	($33)	$9	$108
2105	Range Opert Cent	225	1	A	0.02	49	$4	$46	$77	$9	$0	$86	($0.4)	($4)	$4	$42
2105	Range Opert Cent	227	1	A	0.02	49	$4	$46	$77	$9	$0	$86	($0.4)	($4)	$4	$42
2105	Range Opert Cent	237	1	A	0.02	8	$1	$7	$77	$9	$0	$86	($0.1)	($1)	$1	$7
Totals for Retrofit			17	A	0.27	1,284	$107	$1,204	$1,304	$156	($6)	$1,456	($12)	($126)	$95	$1,078
													SIR	0.74	Payback	15.35
2105	Range Opert Cent	165/166/1	16	B	0.62	2,336	$194	$2,191	$1,337	$160	($8)	$1,489	($19.4)	($208)	$175	$1,983
2105	Range Opert Cent	170/172	12	B	0.47	1,752	$145	$1,643	$1,003	$120	($6)	$1,117	($14.5)	($156)	$131	$1,487
2105	Range Opert Cent	179/180/1	19	B	0.74	2,774	$230	$2,602	$1,587	$190	($9)	$1,769	($23.0)	($247)	$207	$2,355
2105	Range Opert Cent	204/206	43	B	1.68	6,279	$521	$5,889	$3,593	$431	($21)	$4,003	($52.1)	($559)	$469	$5,330
2105	Range Opert Cent	229B	3	B	0.12	304	$25	$285	$251	$30	($1)	$280	($2.3)	($24)	$23	$261
2105	Range Opert Cent	234A	1	B	0.04	3,748	$311	$3,515	$84	$10	$0	$94	($2.5)	($27)	$309	$3,488
2105	Range Opert Cent	236A	3	B	0.12	1,022	$85	$959	$251	$30	($1)	$280	($7.6)	($82)	$77	$877
2105	Range Opert Cent	151	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
2105	Range Opert Cent	155	1	B	0.04	16	$1	$15	$84	$10	$0	$94	($0.1)	($1)	$1	$14
2105	Range Opert Cent	156	5	B	0.20	1,704	$141	$1,598	$418	$50	($2)	$466	($12.7)	($137)	$129	$1,461
2105	Range Opert Cent	157	7	B	0.27	1,022	$85	$959	$585	$70	($3)	$652	($8.5)	($91)	$76	$868
2105	Range Opert Cent	158	9	B	0.35	1,314	$109	$1,233	$752	$90	($4)	$838	($10.9)	($117)	$98	$1,116
2105	Range Opert Cent	159	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	160	17	B	0.66	2,482	$206	$2,328	$1,420	$170	($8)	$1,583	($20.6)	($221)	$185	$2,107
2105	Range Opert Cent	161	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	162	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	163	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	164	6	B	0.23	876	$73	$822	$501	$60	($3)	$558	($7.3)	($78)	$65	$744
2105	Range Opert Cent	167	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	168	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	171	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	173	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	174	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	175	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	176	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	177	6	B	0.23	876	$73	$822	$501	$60	($3)	$558	($7.3)	($78)	$65	$744
2105	Range Opert Cent	178	7	B	0.27	2,385	$198	$2,237	$585	$70	($3)	$652	($17.8)	($191)	$180	$2,046

TABLE H-8 BUILDING 2105 SOUTHSIDE SECOND FLOOR LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	182	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	183	6	B	0.23	876	$73	$822	$501	$60	($3)	$558	($7.3)	($78)	$65	$744
2105	Range Opert Cent	184	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	186	8	B	0.31	1,168	$97	$1,096	$668	$80	($4)	$745	($9.7)	($104)	$87	$992
2105	Range Opert Cent	187	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	188	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	189	15	B	0.59	2,190	$182	$2,054	$1,253	$150	($7)	$1,397	($18.2)	($195)	$164	$1,859
2105	Range Opert Cent	191	1	B	0.04	101	$8	$95	$84	$10	$0	$94	($0.8)	($8)	$8	$87
2105	Range Opert Cent	195	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	196	4	B	0.16	584	$48	$548	$334	$40	($2)	$372	($4.8)	($52)	$44	$496
2105	Range Opert Cent	197	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	198	6	B	0.23	876	$73	$822	$501	$60	($3)	$558	($7.3)	($78)	$65	$744
2105	Range Opert Cent	199	13	B	0.51	1,898	$158	$1,780	$1,086	$130	($6)	$1,210	($15.7)	($169)	$142	$1,611
2105	Range Opert Cent	200	12	B	0.47	1,752	$145	$1,643	$1,003	$120	($6)	$1,117	($14.5)	($156)	$131	$1,487
2105	Range Opert Cent	201	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	202	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	205	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	208	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	209	42	B	1.64	6,133	$509	$5,752	$3,509	$421	($21)	$3,909	($50.8)	($546)	$458	$5,206
2105	Range Opert Cent	210	2	B	0.08	292	$24	$274	$167	$20	($1)	$186	($2.4)	($26)	$22	$248
2105	Range Opert Cent	211	2	B	0.08	292	$24	$274	$167	$20	($1)	$186	($2.4)	($26)	$22	$248
2105	Range Opert Cent	212	9	B	0.35	1,314	$109	$1,233	$752	$90	($4)	$838	($10.9)	($117)	$98	$1,116
2105	Range Opert Cent	213	4	B	0.16	584	$48	$548	$334	$40	($2)	$372	($4.8)	($52)	$44	$496
2105	Range Opert Cent	215	1	B	0.04	341	$28	$320	$84	$10	$0	$94	($2.5)	($27)	$26	$292
2105	Range Opert Cent	216	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	217	8	B	0.31	1,168	$97	$1,096	$668	$80	($4)	$745	($9.7)	($104)	$87	$992
2105	Range Opert Cent	218	47	B	1.83	6,863	$570	$6,437	$3,927	$471	($23)	$4,375	($56.9)	($611)	$513	$5,826
2105	Range Opert Cent	219	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	220	3	B	0.12	438	$36	$411	$251	$30	($1)	$280	($3.6)	($39)	$33	$372
2105	Range Opert Cent	221	5	B	0.20	730	$61	$685	$418	$50	($2)	$466	($6.1)	($65)	$55	$620
2105	Range Opert Cent	222	8	B	0.31	811	$67	$761	$668	$80	($4)	$745	($6.1)	($65)	$61	$696
2105	Range Opert Cent	223	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
2105	Range Opert Cent	228	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
2105	Range Opert Cent	230	3	B	0.12	304	$25	$285	$251	$30	($1)	$280	($2.3)	($24)	$23	$261
2105	Range Opert Cent	231	4	B	0.16	1,363	$113	$1,278	$334	$40	($2)	$372	($10.2)	($109)	$103	$1,169
2105	Range Opert Cent	232	2	B	0.08	681	$57	$639	$167	$20	($1)	$186	($5.1)	($55)	$51	$584
2105	Range Opert Cent	233	1	B	0.04	341	$28	$320	$84	$10	$0	$94	($2.5)	($27)	$26	$292
2105	Range Opert Cent	235	1	B	0.04	341	$28	$320	$84	$10	$0	$94	($2.5)	($27)	$26	$292
Totals for Retrofit			461	B	17.98	75,957	$6,304	$71,240	$38,517	$4,622	($208)	$42,936	($591)	($6,352)	$5,713	$64,888

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TABLE H-8 BUILDING 2105 SOUTHSIDE SECOND FLOOR LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
													SIR	1.51	Payback	7.52
2105	Range Opert Cent	194	6	D	0.33	1,236	$103	$1,159	$1,003	$120	($5)	$1,118	($10.9)	($117)	$92	$1,042
Totals for Retrofit			6	D	0.33	1,236	$103	$1,159	$1,003	$120	($5)	$1,118	($11)	($117)	$92	$1,042
													SIR	0.93	Payback	12.20
2105	Range Opert Cent	229A	12	H	1.26	3,276	$272	$3,073	$1,832	$220	($9)	$2,043	($3.4)	($37)	$268	$3,036
2105	Range Opert Cent	154	3	H	0.32	1,179	$98	$1,106	$458	$55	($2)	$511	($1.4)	($15)	$97	$1,091
2105	Range Opert Cent	190	3	H	0.32	1,179	$98	$1,106	$458	$55	($2)	$511	($1.4)	($15)	$97	$1,091
2105	Range Opert Cent	192	6	H	0.63	2,359	$196	$2,212	$916	$110	($5)	$1,021	($2.7)	($29)	$193	$2,183
2105	Range Opert Cent	207	4	H	0.42	1,572	$131	$1,475	$611	$73	($3)	$681	($1.8)	($20)	$129	$1,455
Totals for Retrofit			28	H	2.94	9,566	$794	$8,972	$4,275	$513	($21)	$4,767	($11)	($115)	$783	$8,857
													SIR	1.86	Payback	6.09
Building Total for SIR > 1.0			489	B H	20.92	85,523	$7,098	$80,212	$42,792	$5,135	($229)	$47,703	($602)	($6,467)	$6,496	$73,744
													SIR	1.55	Payback	7.34
Not included (nic)																
2105	Range Opert Cent	193	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	229C	2	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	203	10	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	226	8	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

TOTAL BLDG (kWH/Yr)   TOTAL LOAD

LIGHTING RETROFIT LEGEND
A. Retrofit Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp
B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
D. Retrofit Unit Cost: 4-Lamp Electronic Ballast & T8 Lamps
H. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

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TABLE H-9 BUILDING 3482 LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
3482	Test Prep Facility	112	38	G	5.28	13,733	$1,140	$12,880	$103,195	$12,383	($19)	$115,560	$463.1	$4,974	$1,603	$17,854
3482	Test Prep Facility	106	2	G	0.28	723	$60	$678	$5,431	$652	($1)	$6,082	$24.4	$262	$84	$940
3482	Test Prep Facility	107	2	G	0.28	723	$60	$678	$5,431	$652	($1)	$6,082	$24.4	$262	$84	$940
3482	Test Prep Facility	118	1	G	0.14	361	$30	$339	$2,716	$326	$0	$3,042	$12.2	$131	$42	$470
3482	Test Prep Facility	119	1	G	0.14	361	$30	$339	$2,716	$326	$0	$3,042	$12.2	$131	$42	$470
3482	Test Prep Facility	101	9	G	1.25	3,253	$270	$3,051	$24,441	$2,933	($4)	$27,370	$109.7	$1,178	$380	$4,229
3482	Test Prep Facility	102	2	G	0.28	723	$60	$678	$5,431	$652	($1)	$6,082	$24.4	$262	$84	$940
3482	Test Prep Facility	103	4	G	0.56	1,446	$120	$1,356	$10,863	$1,304	($2)	$12,164	$48.7	$524	$169	$1,879
3482	Test Prep Facility	104	9	G	1.25	3,253	$270	$3,051	$24,441	$2,933	($4)	$27,370	$109.7	$1,178	$380	$4,229
3482	Test Prep Facility	105	8	G	1.11	2,891	$240	$2,712	$21,725	$2,607	($4)	$24,328	$97.5	$1,047	$337	$3,759
3482	Test Prep Facility	108	9	G	1.25	3,253	$270	$3,051	$24,441	$2,933	($4)	$27,370	$109.7	$1,178	$380	$4,229
3482	Test Prep Facility	109	6	G	0.83	2,168	$180	$2,034	$16,294	$1,955	($3)	$18,246	$73.1	$785	$253	$2,819
3482	Test Prep Facility	110	6	G	0.83	2,168	$180	$2,034	$16,294	$1,955	($3)	$18,246	$73.1	$785	$253	$2,819
3482	Test Prep Facility	111	6	G	0.83	2,168	$180	$2,034	$16,294	$1,955	($3)	$18,246	$73.1	$785	$253	$2,819
3482	Test Prep Facility	113	6	G	0.83	2,168	$180	$2,034	$16,294	$1,955	($3)	$18,246	$73.1	$785	$253	$2,819
3482	Test Prep Facility	114	6	G	0.83	2,168	$180	$2,034	$16,294	$1,955	($3)	$18,246	$73.1	$785	$253	$2,819
3482	Test Prep Facility	115	6	G	0.83	2,168	$180	$2,034	$16,294	$1,955	($3)	$18,246	$73.1	$785	$253	$2,819
3482	Test Prep Facility	116	6	G	0.83	2,168	$180	$2,034	$16,294	$1,955	($3)	$18,246	$73.1	$785	$253	$2,819
3482	Test Prep Facility	117	6	G	0.83	2,168	$180	$2,034	$16,294	$1,955	($3)	$18,246	$73.1	$785	$253	$2,819
3482	Test Prep Facility	121	6	G	0.83	2,168	$180	$2,034	$16,294	$1,955	($3)	$18,246	$73.1	$785	$253	$2,819
3482	Test Prep Facility	122	9	G	1.25	3,253	$270	$3,051	$24,441	$2,933	($4)	$27,370	$109.7	$1,178	$380	$4,229
3482	Test Prep Facility	123	9	G	1.25	3,253	$270	$3,051	$24,441	$2,933	($4)	$27,370	$109.7	$1,178	$380	$4,229
3482	Test Prep Facility	124	9	G	1.25	3,253	$270	$3,051	$24,441	$2,933	($4)	$27,370	$109.7	$1,178	$380	$4,229
3482	Test Prep Facility	120	6	G	0.83	2,168	$180	$2,034	$16,294	$1,955	($3)	$18,246	$73.1	$785	$253	$2,819
Totals for Retrofit			172	G	23.91	62,161	$5,159	$58,301	$467,095	$56,051	($82)	$523,062	$2,096	$22,513	$7,256	$80,814
													SIR	0.15	Payback	72.09

LIGHTING RETROFIT LEGEND G. New Fxtr Unit Cost: 3-Lamp Elect. Bal. & T8 Lamps - Explosion Proof

TOTAL BLDG TOTAL

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

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TABLE H-10 BUILDING 3490 LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
3490	Weapon Eval Fac	09	4	A	0.08	316	$26	$297	$307	$37	($1)	$343	($2.4)	($26)	$24	$271
3490	Weapon Eval Fac	32E	3	A	0.06	237	$20	$222	$230	$28	($1)	$257	($1.8)	($20)	$18	$203
3490	Weapon Eval Fac	10	3	A	0.06	237	$20	$222	$230	$28	($1)	$257	($1.8)	($20)	$18	$203
3490	Weapon Eval Fac	13	3	A	0.06	190	$16	$178	$230	$28	($1)	$257	($1.8)	($20)	$14	$158
3490	Weapon Eval Fac	15	9	A	0.17	569	$47	$534	$690	$83	($2)	$771	($5.4)	($59)	$42	$475
3490	Weapon Eval Fac	17	1	A	0.02	63	$5	$59	$77	$9	$0	$86	($0.6)	($7)	$5	$53
3490	Weapon Eval Fac	22	2	A	0.04	126	$10	$119	$153	$18	($1)	$171	($1.2)	($13)	$9	$106
3490	Weapon Eval Fac	23	3	A	0.06	190	$16	$178	$230	$28	($1)	$257	($1.8)	($20)	$14	$158
Totals for Retrofit			28	A	0.53	1,929	$160	$1,809	$2,148	$258	($8)	$2,399	($17)	($182)	$143	$1,627
													SIR	0.68	Payback	16.76
3490	Weapon Eval Fac	08	10	B	0.39	811	$67	$761	$836	$100	($5)	$931	($12.1)	($130)	$55	$631
3490	Weapon Eval Fac	20A	4	B	0.16	519	$43	$487	$334	$40	($2)	$372	($4.8)	($52)	$38	$435
3490	Weapon Eval Fac	12	1	B	0.04	130	$11	$122	$84	$10	$0	$94	($1.2)	($13)	$10	$109
3490	Weapon Eval Fac	14	1	B	0.04	130	$11	$122	$84	$10	$0	$94	($1.2)	($13)	$10	$109
3490	Weapon Eval Fac	16	2	B	0.08	260	$22	$243	$167	$20	($1)	$186	($2.4)	($26)	$19	$217
3490	Weapon Eval Fac	18	19	B	0.74	1,541	$128	$1,446	$1,587	$190	($9)	$1,769	($23.0)	($247)	$105	$1,199
3490	Weapon Eval Fac	25	1	B	0.04	130	$11	$122	$84	$10	$0	$94	($1.2)	($13)	$10	$109
3490	Weapon Eval Fac	27	20	B	0.78	2,596	$215	$2,435	$1,671	$201	($10)	$1,862	($24.2)	($260)	$191	$2,175
3490	Weapon Eval Fac	28	18	B	0.70	2,336	$194	$2,191	$1,504	$180	($9)	$1,675	($21.8)	($234)	$172	$1,957
3490	Weapon Eval Fac	29	16	B	0.62	2,077	$172	$1,948	$1,337	$160	($8)	$1,489	($19.4)	($208)	$153	$1,740
3490	Weapon Eval Fac	30	20	B	0.78	2,596	$215	$2,435	$1,671	$201	($10)	$1,862	($24.2)	($260)	$191	$2,175
3490	Weapon Eval Fac	31	20	B	0.78	2,596	$215	$2,435	$1,671	$201	($10)	$1,862	($24.2)	($260)	$191	$2,175
3490	Weapon Eval Fac	32	25	B	0.98	3,245	$269	$3,043	$2,089	$251	($12)	$2,327	($30.3)	($325)	$239	$2,718
Totals for Retrofit			157	B	6.12	18,966	$1,574	$17,788	$13,117	$1,574	($76)	$14,617	($190)	($2,041)	$1,384	$15,747
													SIR	1.08	Payback	10.56
3490	Weapon Eval Fac	24	2	C	0.11	366	$30	$343	$202	$24	($2)	$224	($3.6)	($39)	$27	$304
Totals for Retrofit			2	C	0.11	366	$30	$343	$202	$24	($2)	$224	($4)	($39)	$27	$304
													SIR	1.36	Payback	8.37
3490	Weapon Eval Fac	05	3	H	0.32	1,048	$87	$983	$458	$55	($2)	$511	($1.4)	($15)	$86	$969
3490	Weapon Eval Fac	06	4	H	0.42	1,398	$116	$1,311	$611	$73	($3)	$681	($1.8)	($20)	$114	$1,291
3490	Weapon Eval Fac	07A	6	H	0.63	2,097	$174	$1,966	$916	$110	($5)	$1,021	($2.7)	($29)	$171	$1,937
3490	Weapon Eval Fac	07B	4	H	0.42	1,398	$116	$1,311	$611	$73	($3)	$681	($1.8)	($20)	$114	$1,291
3490	Weapon Eval Fac	20B	2	H	0.21	699	$58	$655	$305	$37	($2)	$340	($0.9)	($10)	$57	$646
3490	Weapon Eval Fac	32A	8	H	0.84	2,796	$232	$2,622	$1,222	$147	($6)	$1,362	($3.6)	($39)	$228	$2,583
3490	Weapon Eval Fac	32B	4	H	0.42	1,398	$116	$1,311	$611	$73	($3)	$681	($1.8)	($20)	$114	$1,291
3490	Weapon Eval Fac	32C	4	H	0.42	1,398	$116	$1,311	$611	$73	($3)	$681	($1.8)	($20)	$114	$1,291

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TABLE H-10 BUILDING 3490 LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Room No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
3490	Weapon Eval Fac	32D	4	H	0.42	1,398	$116	$1,311	$611	$73	($3)	$681	($1.8)	($20)	$114	$1,291
Totals for Retrofit			39	H	4.10	13,628	$1,131	$12,782	$5,955	$715	($30)	$6,639	($18)	($191)	$1,113	$12,591
													SIR	1.90	Payback	5.96
Totals for SIR > 1.0			**198**	**B C H**	**10.33**	**32,960**	**$2,736**	**$30,913**	**$19,274**	**$2,313**	**($108)**	**$21,480**	**($211)**	**($2,271)**	**$2,524**	**$28,642**
													SIR	**1.33**	**Payback**	**8.51**
Not included (nic)																
3490	Weapon Eval Fac	11	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	26	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	21	1	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	33	4	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	02	57	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	01	38	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	04	64	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	03	60	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	19	BY MFG	-	0.00	0	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND
A. Retrofit Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp
B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps
C. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps
H. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

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TABLE H-11 BUILDING 3510 LIGHTING RETROFIT EVALUATION

Bldg No	Building Name	Roo No	No of Fixtures	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
3510	Ord Accept Test Fac	201	6	G	0.83	347	$29	$325	$16,294	$1,955	($3)	$18,246	$11.7	$126	$40	$451
3510	Ord Accept Test Fac	202	6	G	0.83	347	$29	$325	$16,294	$1,955	($3)	$18,246	$11.7	$126	$40	$451
3510	Ord Accept Test Fac	203	6	G	0.83	347	$29	$325	$16,294	$1,955	($3)	$18,246	$11.7	$126	$40	$451
Totals for Retrofit			18	G	2.50	1,041	$86	$976	$48,882	$5,866	($9)	$54,738	$35	$377	$121	$1,353
													SIR	0.02	Payback	450.56

LIGHTING RETROFIT LEGEND G. New Fxtr Unit Cost: 3-Lamp Elect. Bal. & T8 Lamps - Explosion Proof

Note: kWH savings of lighting retrofits include effects of cooling load reduction assuming an EER of 10.0

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TABLE H-12 BUILDING 451 LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Deman (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
451	NCO Open Mess (R)	4	8	J	0.00	200	$17	$187	$130	$16	$0	$146	$0.0	$0	$16.59	$187
451	NCO Open Mess	4	8	J	0.00	983	$82	$922	$130	$16	$0	$146	$0.0	$0	$81.57	$922
451	NCO Open Mess (R)	5	8	J	0.00	200	$17	$187	$130	$16	$0	$146	$0.0	$0	$16.59	$187
451	NCO Open Mess	5	8	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$6.80	$77
451	NCO Open Mess (R)	8	4	J	0.00	500	$41	$469	$130	$16	$0	$146	$0.0	$0	$41.47	$469
451	NCO Open Mess	17	8	J	0.00	637	$53	$597	$130	$16	$0	$146	$0.0	$0	$52.87	$597
451	NCO Open Mess	18	8	J	0.00	546	$45	$512	$130	$16	$0	$146	$0.0	$0	$45.32	$512
451	NCO Open Mess	18	8	J	0.00	728	$60	$683	$130	$16	$0	$146	$0.0	$0	$60.42	$683
Totals for Retrofit				J	0.00	3,875	$322	$3,634	$1,041	$125	$0	$1,166	$0	$0	$322	$3,634
													SIR	3.12	Payback	3.63
Not included (nic)																
451	NCO Open Mess (R)	10A	12	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess (R)	10B	12	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess (R)	1	1	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess (R)	1	1	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	2	16	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess (R)	3	1	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	6	14	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess (R)	7	1	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess (R)	9	17	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	9	17	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess (R)	11	12	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess (R)	12	18	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	13	3	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess (R)	13	3	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess (R)	13	3	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	14	3	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	14	3	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	14	3	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	15	12	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	16	12	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	19	1	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	20	12	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	21	2	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	22	2	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	23	12	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
451	NCO Open Mess	24	15	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND J. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Automatic Wall Switch
NCO Open Mess (R) = With recommended lighting retrofit

TABLE H-13 BUILDING 506A LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506A	E M Barracks	100	16	I	0.00	629	$52	$590	$149	$18	$0	$167	$0.0	$0	$52	$590
506A	E M Barracks	100	16	I	0.00	314	$26	$295	$149	$18	$0	$167	$0.0	$0	$26	$295
Totals for Retrofit				I	0.00	943	$78	$885	$299	$36	$0	$334	$0	$0	$78	$885
													SIR	2.65	Payback	4.27
506A	E M Barracks	108A	8	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	EM Barracks (R)	108B	8	J	0.00	85	$7	$80	$130	$16	$0	$146	$0.0	$0	$7	$80
506A	E M Barracks	207A	8	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks (R)	207B	8	J	0.00	85	$7	$80	$130	$16	$0	$146	$0.0	$0	$7	$80
506A	E M Barracks	212A	8	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks (R)	212B	8	J	0.00	85	$7	$80	$130	$16	$0	$146	$0.0	$0	$7	$80
506A	E M Barracks	307A	8	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks (R)	307B	8	J	0.00	85	$7	$80	$130	$16	$0	$146	$0.0	$0	$7	$80
506A	E M Barracks	312A	8	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks (R)	312B	8	J	0.00	85	$7	$80	$130	$16	$0	$146	$0.0	$0	$7	$80
506A	E M Barracks	101	4	J	0.00	393	$33	$369	$130	$16	$0	$146	$0.0	$0	$33	$369
506A	E M Barracks	102	4	J	0.00	79	$7	$74	$130	$16	$0	$146	$0.0	$0	$7	$74
506A	E M Barracks	103	4	J	0.00	79	$7	$74	$130	$16	$0	$146	$0.0	$0	$7	$74
506A	E M Barracks	104	4	J	0.00	157	$13	$147	$130	$16	$0	$146	$0.0	$0	$13	$147
506A	E M Barracks	106	7	J	0.00	144	$12	$135	$130	$16	$0	$146	$0.0	$0	$12	$135
506A	E M Barracks	107	4	J	0.00	78	$6	$73	$130	$16	$0	$146	$0.0	$0	$6	$73
506A	E M Barracks	109	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	110	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	111	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	112	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	113	9	J	0.00	98	$8	$92	$130	$16	$0	$146	$0.0	$0	$8	$92
506A	E M Barracks	114	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	115	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	116	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	117	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	118	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	119	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	120	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	121	4	J	0.00	157	$13	$147	$130	$16	$0	$146	$0.0	$0	$13	$147
506A	E M Barracks	122	4	J	0.00	472	$39	$442	$130	$16	$0	$146	$0.0	$0	$39	$442
506A	E M Barracks	123	4	J	0.00	314	$26	$295	$130	$16	$0	$146	$0.0	$0	$26	$295
506A	E M Barracks	124	4	J	0.00	472	$39	$442	$130	$16	$0	$146	$0.0	$0	$39	$442
506A	E M Barracks	201	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	202	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	203	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	204	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	205	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77

TABLE H-13 BUILDING 506A LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506A	E M Barracks	206	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	208	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	210	9	J	0.00	164	$14	$154	$130	$16	$0	$146	$0.0	$0	$14	$154
506A	E M Barracks	211	9	J	0.00	164	$14	$154	$130	$16	$0	$146	$0.0	$0	$14	$154
506A	E M Barracks	213	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	214	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	215	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	216	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	217	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	218	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	219	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	220	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	221	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	223	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	224	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	226	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	227	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	228	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	229	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	230	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	231	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	232	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	233	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	235	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	236	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	237	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	238	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	239	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	240	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	301	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	302	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	303	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	304	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	305	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	306	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	308	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	310	9	J	0.00	164	$14	$154	$130	$16	$0	$146	$0.0	$0	$14	$154
506A	E M Barracks	311	9	J	0.00	164	$14	$154	$130	$16	$0	$146	$0.0	$0	$14	$154
506A	E M Barracks	313	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	314	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	315	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77

TABLE H-13 BUILDING 506A LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506A	E M Barracks	316	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	317	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	318	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	319	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	320	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	321	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	322	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	323	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	324	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	326	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	327	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	328	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	329	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	330	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	331	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	332	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	333	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	335	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	336	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	337	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	338	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	339	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
506A	E M Barracks	340	9	J	0.00	82	$7	$77	$130	$16	$0	$146	$0.0	$0	$7	$77
Totals for Retrofit				J	0.00	10,158	$843	$9,527	$13,148	$1,578	$0	$14,746	$0	$0	$843	$9,527
													SIR	0.65	Payback	17.49
506A	E M Barracks	B2	1	I	0.00	157	$13	$147	$299	$34	$0	$333	$0.0	$0	$13	$147
506A	E M Barracks (R)	125	1	I	0.00	127	$11	$119	$299	$34	$0	$333	$0.0	$0	$11	$119
506A	E M Barracks (R)	126	1	I	0.00	127	$11	$119	$299	$34	$0	$333	$0.0	$0	$11	$119
506A	E M Barracks (R)	127	1	5I	0.00	887	$74	$832	$1,493	$172	$0	$1,664	$0.0	$0	$74	$832
506A	E M Barracks (R)	225	1	I	0.00	127	$11	$119	$299	$34	$0	$333	$0.0	$0	$11	$119
506A	E M Barracks (R)	234	1	I	0.00	127	$11	$119	$299	$34	$0	$333	$0.0	$0	$11	$119
506A	E M Barracks (R)	241	1	5I	0.00	1,203	$100	$1,129	$1,493	$172	$0	$1,664	$0.0	$0	$100	$1,129
506A	E M Barracks (R)	325	1	I	0.00	95	$8	$89	$299	$34	$0	$333	$0.0	$0	$8	$89
506A	E M Barracks (R)	334	1	I	0.00	95	$8	$89	$299	$34	$0	$333	$0.0	$0	$8	$89
506A	E M Barracks (R)	341	1	5I	0.00	903	$75	$846	$1,493	$172	$0	$1,664	$0.0	$0	$75	$846
Totals for Retrofit				I	0.00	3,847	$319	$3,608	$6,568	$755	$0	$7,323	$0	$0	$319	$3,608
													SIR	0.49	Payback	22.94
Not included (nic)																
506A	E M Barracks	B1	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	B3	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	108C	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

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TABLE H-13 BUILDING 506A LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506A	E M Barracks	207C	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	212C	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	307C	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	312C	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	105	15	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	209	15	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	309	15	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	128	17	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	128	17	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks (R)	128	17	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks (R)	129	18	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506A	E M Barracks	129	18	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND **I. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Ceiling Mounted**
J. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Automatic Wall Switch
EM Barracks (R) = With recommended lighting retrofit

TABLE H-14 BUILDING 506B LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks (R)	131	1	I	0.00	266.45	$22	$250	$299	$36	$0	$334	$0.0	$0	$22	$250
506B	E M Barracks (R)	132	1	-	included	included	included	included	included	included	included	included	included	included	included	included
506B	E M Barracks (R)	132	1	5I	0.00	2,531.26	$210	$2,374	$1,493	$179	$0	$1,672	$0.0	$0	$210	$2,374
506B	E M Barracks (R)	134	1	I	0.00	266.45	$22	$250	$299	$36	$0	$334	$0.0	$0	$22	$250
506B	E M Barracks (R)	232	1	I	0.00	399.67	$33	$375	$299	$36	$0	$334	$0.0	$0	$33	$375
506B	E M Barracks (R)	235	1	5I	0.00	2,131.58	$177	$1,999	$1,493	$179	$0	$1,672	$0.0	$0	$177	$1,999
506B	E M Barracks (R)	236	1	0.5I	0.00	133.22	$11	$125	$149	$18	$0	$167	$0.0	$0	$11	$125
506B	E M Barracks (R)	236	1	0.5I	0.00	266.45	$22	$250	$149	$18	$0	$167	$0.0	$0	$22	$250
506B	E M Barracks (R)	332	1	I	0.00	399.67	$33	$375	$299	$36	$0	$334	$0.0	$0	$33	$375
506B	E M Barracks (R)	335	1	5I	0.00	2,131.58	$177	$1,999	$1,493	$179	$0	$1,672	$0.0	$0	$177	$1,999
506B	E M Barracks (R)	336	1	I	0.00	399.67	$33	$375	$299	$36	$0	$334	$0.0	$0	$33	$375
Totals for Corridors				I	0.00	8,926	$741	$8,372	$6,270	$752	$0	$7,020	$0	$0	$741	$8,372
													SIR	1.19	Payback	9.48
Motion Senors for Offices																
506B	E M Barracks	138	4	I	0.00	943.49	$78	$885	$299	$36	$0	$334	$0.0	$0	$78	$885
506B	E M Barracks (R)	146	4	I	0.00	359.70	$30	$337	$299	$36	$0	$334	$0.0	$0	$30	$337
Totals for Offices				I	0.00	1,303	$108	$1,222	$597	$72	$0	$668	$0	$0	$108	$1,222
													SIR	1.83	Payback	6.18
506B	E M Barracks (R)	101	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	101	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	102	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	102	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	103	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	103	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	104	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	104	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	105	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	105	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	106	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	106	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	107	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	107	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	108	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	108	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	109	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	109	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	110	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	110	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	111	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	111	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	112	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48

TABLE H-14 BUILDING 506B LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks (R)	112	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	113	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	113	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	114	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	114	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	115	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	115	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	116	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	116	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	117	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	117	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	118	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	118	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	119	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	119	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	120	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	120	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	121	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	121	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	122	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	122	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	123	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	123	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	124	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	124	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	125	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	125	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	126	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	126	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	127	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	127	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	128	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	128	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	129	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	129	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	130	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	130	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	137	16	J	0.00	399.67	$33	$375	$130	$16	$0	$146	$0.0	$0	$33	$375
506B	E M Barracks	139	4	J	0.00	235.87	$20	$221	$130	$16	$0	$146	$0.0	$0	$20	$221
506B	E M Barracks (R)	143	8	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	143	8	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	144	8	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47

TABLE H-14 BUILDING 506B LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks (R)	201	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	201	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	202	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	202	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	203	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	203	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	204	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	204	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	205	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	205	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	206	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	206	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	207	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	207	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	208	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	208	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	209	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	209	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	210	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	210	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	211	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	211	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	212	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	212	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	213	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	213	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	214	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	214	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	215	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	215	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	216	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	216	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	217	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	217	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	218	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	218	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	219	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	219	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	220	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	220	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	221	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	221	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks (R)	222	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	222	8	J	0.00	54.16	$4	$51	$130	$16	$0	$146	$0.0	$0	$4	$51
506B	E M Barracks (R)	223	9	J	0.00	49.96	$4	$47	$130	$16	$0	$146	$0.0	$0	$4	$47
506B	E M Barracks (R)	223	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	224	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	224	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	225	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	225	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	226	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	226	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	227	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	227	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	228	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	228	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	229	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	229	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	301	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	301	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	302	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	302	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	303	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	303	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	304	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	304	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	305	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	305	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	306	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	306	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	307	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	307	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	308	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	308	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	309	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	309	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	310	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	310	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	311	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	311	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	312	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	312	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	313	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	313	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50

TABLE H-14 BUILDING 506B LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks (R)	314	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	314	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	315	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	315	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	316	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	316	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	317	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	317	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	318	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	318	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	319	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	319	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	320	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	320	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	321	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	321	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	322	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	322	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	323	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	323	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	324	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	324	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	325	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	325	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	326	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	326	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	327	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	327	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	328	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	328	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
506B	E M Barracks (R)	329	8	J	0.00	50.78	$4	$48	$130	$16	$0	$146	$0.0	$0	$4	$48
506B	E M Barracks (R)	329	9	J	0.00	53.29	$4	$50	$130	$16	$0	$146	$0.0	$0	$4	$50
Totals for Retrofit				J	0.00	9,841	$817	$9,230	$23,563	$2,828	$0	$26,426	$0	$0	$817	$9,230
													SIR	0.35	Payback	32.35
Totals for SIR > 1				I Only	0.00	10,229	$849	$9,594	$6,867	$824	$0	$7,688	$0	$0	$849	$9,594
													SIR	1.25	Payback	9.06
Not included (nic)																
506B	E M Barracks (R)	100	7	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	133	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks (R)	135	3	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks (R)	136	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

TABLE H-14 BUILDING 506B LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
506B	E M Barracks	140	17	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks (R)	141	17	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks (R)	142	17	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks (R)	145	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	200	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks (R)	230	2	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks (R)	231	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	233	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	234	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	237	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	238	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	300	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks (R)	330	2	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks (R)	331	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	333	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	334	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	337	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
506B	E M Barracks	338	15	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND **I. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Ceiling Mounted**
J. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Automatic Wall Switch

E M Barracks (R) = Rooms evaluated with recommended lighting retrofits installed.

TABLE H-15 BUILDING 2105 NORTHSIDE FIRST FLOOR LIGHTING CONTROLS RETROFIT

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent (R)	15,16	4	I	0.00	1,156	$96	$1,084	$299	$36	$0	$334	$0.0	$0	$96	$1,084
2105	Range Opert Cent (R)	3,5,7	4	I	0.00	1,867	$155	$1,751	$299	$36	$0	$334	$0.0	$0	$155	$1,751
2105	Range Opert Cent (R)	32	4	I	0.00	571	$47	$536	$299	$36	$0	$334	$0.0	$0	$47	$536
2105	Range Opert Cent (R)	33	4	I	0.00	571	$47	$536	$299	$36	$0	$334	$0.0	$0	$47	$536
2105	Range Opert Cent (R)	34	4	I	0.00	571	$47	$536	$299	$36	$0	$334	$0.0	$0	$47	$536
2105	Range Opert Cent (R)	45	4	I	0.00	1,423	$118	$1,334	$299	$36	$0	$334	$0.0	$0	$118	$1,334
2105	Range Opert Cent (R)	50	4	I	0.00	1,423	$118	$1,334	$299	$36	$0	$334	$0.0	$0	$118	$1,334
2105	Range Opert Cent (R)	63	4	I	0.00	571	$47	$536	$299	$36	$0	$334	$0.0	$0	$47	$536
2105	Range Opert Cent (R)	9	4	I	0.00	685	$57	$643	$299	$36	$0	$334	$0.0	$0	$57	$643
2105	Range Opert Cent (R)	52	4	I2	0.00	2,223	$185	$2,085	$597	$72	$0	$669	$0.0	$0	$185	$2,085
2105	Range Opert Cent (R)	59	4	I2	0.00	1,956	$162	$1,835	$597	$72	$0	$669	$0.0	$0	$162	$1,835
2105	Range Opert Cent (R)	4	4	I4	0.00	5,335	$443	$5,004	$1,194	$143	$0	$1,338	$0.0	$0	$443	$5,004
Totals for Retrofit				I	0.00	18,352	$1,523	$17,212	$5,075	$609	$0	$5,684	$0	$0	$1,523	$17,212
													SIR	3.03	Payback	3.73
2105	Range Opert Cent (R)	10	4	J	0.00	711	$59	$667	$130	$16	$0	$146	$0.0	$0	$59	$667
2105	Range Opert Cent (R)	11	4	J	0.00	948	$79	$889	$130	$16	$0	$146	$0.0	$0	$79	$889
2105	Range Opert Cent (R)	12	4	J	0.00	237	$20	$222	$130	$16	$0	$146	$0.0	$0	$20	$222
2105	Range Opert Cent (R)	13	4	J	0.00	237	$20	$222	$130	$16	$0	$146	$0.0	$0	$20	$222
2105	Range Opert Cent (R)	14	4	J	0.00	237	$20	$222	$130	$16	$0	$146	$0.0	$0	$20	$222
2105	Range Opert Cent (R)	17	4	J	0.00	948	$79	$889	$130	$16	$0	$146	$0.0	$0	$79	$889
2105	Range Opert Cent (R)	18	4	J	0.00	237	$20	$222	$130	$16	$0	$146	$0.0	$0	$20	$222
2105	Range Opert Cent (R)	19	4	J	0.00	355	$29	$333	$130	$16	$0	$146	$0.0	$0	$29	$333
2105	Range Opert Cent (R)	2	4	J	0.00	948	$79	$889	$130	$16	$0	$146	$0.0	$0	$79	$889
2105	Range Opert Cent (R)	23	4	J	0.00	456	$38	$428	$130	$16	$0	$146	$0.0	$0	$38	$428
2105	Range Opert Cent (R)	24	4	J	0.00	532	$44	$499	$130	$16	$0	$146	$0.0	$0	$44	$499
2105	Range Opert Cent (R)	2A	4	J	0.00	948	$79	$889	$130	$16	$0	$146	$0.0	$0	$79	$889
2105	Range Opert Cent (R)	30	4	J	0.00	456	$38	$428	$130	$16	$0	$146	$0.0	$0	$38	$428
2105	Range Opert Cent (R)	31	4	J	0.00	608	$50	$571	$130	$16	$0	$146	$0.0	$0	$50	$571
2105	Range Opert Cent (R)	35	4	J	0.00	228	$19	$214	$130	$16	$0	$146	$0.0	$0	$19	$214
2105	Range Opert Cent (R)	36	4	J	0.00	380	$32	$357	$130	$16	$0	$146	$0.0	$0	$32	$357
2105	Range Opert Cent (R)	3A	4	J	0.00	474	$39	$444	$130	$16	$0	$146	$0.0	$0	$39	$444
2105	Range Opert Cent (R)	46	4	J	0.00	474	$39	$444	$130	$16	$0	$146	$0.0	$0	$39	$444
2105	Range Opert Cent (R)	47	4	J	0.00	237	$20	$222	$130	$16	$0	$146	$0.0	$0	$20	$222
2105	Range Opert Cent (R)	48	4	J	0.00	948	$79	$889	$130	$16	$0	$146	$0.0	$0	$79	$889
2105	Range Opert Cent (R)	53	4	J	0.00	152	$13	$143	$130	$16	$0	$146	$0.0	$0	$13	$143
2105	Range Opert Cent (R)	54	4	J	0.00	237	$20	$222	$130	$16	$0	$146	$0.0	$0	$20	$222
2105	Range Opert Cent (R)	55	4	J	0.00	237	$20	$222	$130	$16	$0	$146	$0.0	$0	$20	$222

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TABLE H-15 BUILDING 2105 NORTHSIDE FIRST FLOOR LIGHTING CONTROLS RETROFIT

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent (R)	56	4	J	0.00	237	$20	$222	$130	$16	$0	$146	$0.0	$0	$20	$222
2105	Range Opert Cent (R)	6	4	J	0.00	711	$59	$667	$130	$16	$0	$146	$0.0	$0	$59	$667
2105	Range Opert Cent (R)	60	4	J	0.00	948	$79	$889	$130	$16	$0	$146	$0.0	$0	$79	$889
2105	Range Opert Cent (R)	61	4	J	0.00	355	$29	$333	$130	$16	$0	$146	$0.0	$0	$29	$333
2105	Range Opert Cent (R)	62	4	J	0.00	355	$29	$333	$130	$16	$0	$146	$0.0	$0	$29	$333
2105	Range Opert Cent (R)	8	4	J	0.00	711	$59	$667	$130	$16	$0	$146	$0.0	$0	$59	$667
Totals for Retrofit				J	0.00	14,540	$1,207	$13,637	$3,775	$453	$0	$4,228	$0	$0	$1,207	$13,637
													SIR	3.23	Payback	3.50
Totals for SIR > 1.0				I & J	0.00	32,892	$2,730	$30,849	$8,851	$1,062	$0	$9,913	$0	$0	$2,730	$30,849
													SIR	3.11	Payback	3.83
Not included (nic)																
2105	Range Opert Cent (R)	1	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent (R)	20	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	21	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent (R)	22	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent (R)	25	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent (R)	26	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent (R)	27	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	37	10	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	38	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent (R)	40	8	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	41	15	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent (R)	44	8	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	44	8	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	44	8	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	58	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	58A	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND **I. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Ceiling Mounted**
J. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Automatic Wall Switch

Notes: APS states that occupancy sensors normally save about 25% (min) of lighting energy use. With little local switching available in this building, and limited occupancy in many offices, energy savings are assumed 33% for J type retrofits; I type retrofits are designated for larger areas, thus, 25% is used.

Range Opert Cent (R) indicates rooms where lighting retrofit evaluations resulted in SIR's > 1.0; these retrofits are assumed accomplished before occupancy sensors are installed.

TABLE H-16 BUILDING 2105 SOUTHSIDE FIRST FLOOR LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	119B	4	I	0.00	874	$73	$819	$299	$36	$0	$334	$0.0	$0	$73	$819
2105	Range Opert Cent	69	4	I	0.00	998	$83	$936	$299	$36	$0	$334	$0.0	$0	$83	$936
2105	Range Opert Cent	72	4	I	0.00	1,497	$124	$1,404	$299	$36	$0	$334	$0.0	$0	$124	$1,404
2105	Range Opert Cent	74	4	I2	0.00	4,118	$342	$3,862	$597	$72	$0	$669	$0.0	$0	$342	$3,862
2105	Range Opert Cent	85	8	I	0.00	1,165	$97	$1,092	$299	$36	$0	$334	$0.0	$0	$97	$1,092
2105	Range Opert Cent	85	8	included	included	included	included	included	included	included	included	included	included	included	included	included
2105	Range Opert Cent (R)	100	4	I2	0.00	3,319	$276	$3,113	$597	$72	$0	$669	$0.0	$0	$276	$3,113
2105	Range Opert Cent	101	4	I	0.00	1,685	$140	$1,580	$299	$36	$0	$334	$0.0	$0	$140	$1,580
2105	Range Opert Cent	132	8	I	0.00	582	$48	$546	$299	$36	$0	$334	$0.0	$0	$48	$546
2105	Range Opert Cent	133	8	I	0.00	582	$48	$546	$299	$36	$0	$334	$0.0	$0	$48	$546
2105	Range Opert Cent	136	8	I	0.00	582	$48	$546	$299	$36	$0	$334	$0.0	$0	$48	$546
2105	Range Opert Cent	139	8	I	0.00	582	$48	$546	$299	$36	$0	$334	$0.0	$0	$48	$546
2105	Range Opert Cent	140	8	I	0.00	2,329	$193	$2,185	$299	$36	$0	$334	$0.0	$0	$193	$2,185
Totals for Retrofit				I	0.00	18,315	$1,520	$17,177	$4,180	$502	$0	$4,681	$0	$0	$1,520	$17,177
													SIR	3.87	Payback	3.08
2105	Range Opert Cent	105B	4	J	0.00	187	$16	$176	$130	$16	$0	$146	$0.0	$0	$16	$176
2105	Range Opert Cent	117A	4	J	0.00	421	$35	$395	$130	$16	$0	$146	$0.0	$0	$35	$395
2105	Range Opert Cent	117B	4	J	0.00	140	$12	$132	$130	$16	$0	$146	$0.0	$0	$12	$132
2105	Range Opert Cent	117C	4	J	0.00	140	$12	$132	$130	$16	$0	$146	$0.0	$0	$12	$132
2105	Range Opert Cent (R)	119A	4	J	0.00	178	$15	$167	$130	$16	$0	$146	$0.0	$0	$15	$167
2105	Range Opert Cent	120A	16	J	0.00	20	$2	$18	$130	$16	$0	$146	$0.0	$0	$2	$18
2105	Range Opert Cent	79A	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent	79B	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent	85C	4	J	0.00	562	$47	$527	$130	$16	$0	$146	$0.0	$0	$47	$527
2105	Range Opert Cent	86A	4	J	0.00	140	$12	$132	$130	$16	$0	$146	$0.0	$0	$12	$132
2105	Range Opert Cent	87C	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent	94B	4	J	0.00	562	$47	$527	$130	$16	$0	$146	$0.0	$0	$47	$527
2105	Range Opert Cent (R)	70	4	J	0.00	178	$15	$167	$130	$16	$0	$146	$0.0	$0	$15	$167
2105	Range Opert Cent (R)	71	4	J	0.00	178	$15	$167	$130	$16	$0	$146	$0.0	$0	$15	$167
2105	Range Opert Cent	73	4	J	0.00	562	$47	$527	$130	$16	$0	$146	$0.0	$0	$47	$527
2105	Range Opert Cent	75	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent	76	4	J	0.00	421	$35	$395	$130	$16	$0	$146	$0.0	$0	$35	$395
2105	Range Opert Cent	77	4	J	0.00	421	$35	$395	$130	$16	$0	$146	$0.0	$0	$35	$395
2105	Range Opert Cent	80	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent	81	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent	86	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent	88	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent	95	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	96	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	97	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent (R)	99	4	J	0.00	178	$15	$167	$130	$16	$0	$146	$0.0	$0	$15	$167

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Revised June 1994

TABLE H-16 BUILDING 2105 SOUTHSIDE FIRST FLOOR LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	102	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	103	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	104	4	J	0.00	562	$47	$527	$130	$16	$0	$146	$0.0	$0	$47	$527
2105	Range Opert Cent	109	16	J	0.00	33	$3	$30	$130	$16	$0	$146	$0.0	$0	$3	$30
2105	Range Opert Cent	110	16	J	0.00	33	$3	$30	$130	$16	$0	$146	$0.0	$0	$3	$30
2105	Range Opert Cent	111	4	J	0.00	187	$16	$176	$130	$16	$0	$146	$0.0	$0	$16	$176
2105	Range Opert Cent	112	4	J	0.00	702	$58	$658	$130	$16	$0	$146	$0.0	$0	$58	$658
2105	Range Opert Cent	113	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent (R)	114	4	J	0.00	178	$15	$167	$130	$16	$0	$146	$0.0	$0	$15	$167
2105	Range Opert Cent (R)	115	4	J	0.00	178	$15	$167	$130	$16	$0	$146	$0.0	$0	$15	$167
2105	Range Opert Cent	116	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent	118	4	J	0.00	421	$35	$395	$130	$16	$0	$146	$0.0	$0	$35	$395
2105	Range Opert Cent	121	4	J	0.00	281	$23	$263	$130	$16	$0	$146	$0.0	$0	$23	$263
2105	Range Opert Cent	125	4	J	0.00	187	$16	$176	$130	$16	$0	$146	$0.0	$0	$16	$176
2105	Range Opert Cent	126	4	J	0.00	187	$16	$176	$130	$16	$0	$146	$0.0	$0	$16	$176
2105	Range Opert Cent	127	4	J	0.00	562	$47	$527	$130	$16	$0	$146	$0.0	$0	$47	$527
2105	Range Opert Cent (R)	128	4	J	0.00	356	$30	$334	$130	$16	$0	$146	$0.0	$0	$30	$334
2105	Range Opert Cent	134	8	J	0.00	262	$22	$246	$130	$16	$0	$146	$0.0	$0	$22	$246
2105	Range Opert Cent	141	8	J2	0.00	524	$44	$492	$260	$31	$0	$292	$0.0	$0	$44	$492
Totals for Retrofit				**J**	**0.00**	**13,619**	**$1,130**	**$12,773**	**$5,988**	**$719**	**$0**	**$6,707**	**$0**	**$0**	**$1,130**	**$12,773**
													SIR	**1.90**	**Payback**	**5.93**
Totals for Building				**I & J**	**0.00**	**31,934**	**$2,650**	**$29,951**	**$10,168**	**$1,220**	**$0**	**$11,388**	**$0**	**$0**	**$2,650**	**$29,951**
													SIR	**2.63**	**Payback**	**4.30**
Not included (nic)																
2105	Range Opert Cent	105A	11	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	108A	11	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	108B	11	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent (R)	120B	11	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	122A	11	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent (R)	122B	11	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	83A	14	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	83B	12	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	87A	15	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	87B	15	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	90A	3	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	91A	2	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	91B	2	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	91C	2	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	94A	12	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	65	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

TABLE H-16 BUILDING 2105 SOUTHSIDE FIRST FLOOR LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	66	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	67	14	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	68	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	78	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	82	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	83	14	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	84	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	89	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	92	2	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent (R)	93	12	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	98	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	106	11	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	124	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	130	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	131	8	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	136	8	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	137	15	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	138	8	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	139	8	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	142	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	145	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	146	1	-	-	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND **I. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Ceiling Mounted**
J. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Automatic Wall Switch

Notes: **APS states that occupancy sensors normally save about 25% (min) of lighting energy use. With little local switching available in this building, and limited occupancy in many offices, energy savings are assumed 33% for J type retrofits; I type retrofits are designated for larger areas, thus, 25% is used.**

Range Opert Cent (R) indicates rooms where lighting retrofit evaluations resulted in SIR's > 1.0; these retrofits are assumed accomplished before occupancy sensors are installed.

TABLE H-17 BUILDING 2105 SOUTHSIDE SECOND FLOOR LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	170/172	4	I	0.00	1,123	$93	$1,053	$299	$36	$0	$334	$0.0	$0	$93	$1,053
2105	Range Opert Cent	179/180/181	4	I2	0.00	1,778	$148	$1,668	$597	$72	$0	$669	$0.0	$0	$148	$1,668
2105	Range Opert Cent	204/206	4	I4	0.00	4,025	$334	$3,775	$1,194	$143	$0	$1,338	$0.0	$0	$334	$3,775
2105	Range Opert Cent	234B	8	I	0.00	135	$11	$127	$299	$36	$0	$334	$0.0	$0	$11	$127
2105	Range Opert Cent	236A	8	I	0.00	655	$54	$615	$299	$36	$0	$334	$0.0	$0	$54	$615
2105	Range Opert Cent	157	4	I	0.00	655	$54	$615	$299	$36	$0	$334	$0.0	$0	$54	$615
2105	Range Opert Cent	158	4	I	0.00	842	$70	$790	$299	$36	$0	$334	$0.0	$0	$70	$790
2105	Range Opert Cent	160	4	I2	0.00	1,591	$132	$1,492	$597	$72	$0	$669	$0.0	$0	$132	$1,492
2105	Range Opert Cent	164	4	I	0.00	562	$47	$527	$299	$36	$0	$334	$0.0	$0	$47	$527
2105	Range Opert Cent	186	4	I	0.00	749	$62	$702	$299	$36	$0	$334	$0.0	$0	$62	$702
2105	Range Opert Cent	189	4	I2	0.00	1,404	$117	$1,317	$597	$72	$0	$669	$0.0	$0	$117	$1,317
2105	Range Opert Cent	199	4	I2	0.00	1,217	$101	$1,141	$597	$72	$0	$669	$0.0	$0	$101	$1,141
2105	Range Opert Cent	200	4	I2	0.00	1,123	$93	$1,053	$597	$72	$0	$669	$0.0	$0	$93	$1,053
2105	Range Opert Cent	203	4	I2	0.00	936	$78	$878	$597	$72	$0	$669	$0.0	$0	$78	$878
2105	Range Opert Cent	209	4	I4	0.00	3,931	$326	$3,687	$1,194	$143	$0	$1,338	$0.0	$0	$326	$3,687
2105	Range Opert Cent	218	4	I4	0.00	4,399	$365	$4,126	$1,194	$143	$0	$1,338	$0.0	$0	$365	$4,126
2105	Range Opert Cent	233	8	I	0.00	218	$18	$205	$299	$36	$0	$334	$0.0	$0	$18	$205
Totals for Retrofit				I	0.00	25,345	$2,104	$23,771	$9,554	$1,146	$0	$10,700	$0	$0	$2,104	$23,771
													SIR	2.22	Payback	5.09
2105	Range Opert Cent (R)	154	4	J	0.00	748	$62	$702	$130	$16	$0	$146	$0.0	$0	$62	$702
2105	Range Opert Cent	155	16	J	0.00	14	$1	$13	$130	$16	$0	$146	$0.0	$0	$1	$13
2105	Range Opert Cent	159	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	161	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	162	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	163	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	167	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	168	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	171	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	173	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	174	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	175	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	176	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	177	4	J	0.00	748	$62	$702	$130	$16	$0	$146	$0.0	$0	$62	$702
2105	Range Opert Cent	182	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	183	4	J	0.00	748	$62	$702	$130	$16	$0	$146	$0.0	$0	$62	$702
2105	Range Opert Cent	184	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	187	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	188	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585

TABLE H-17 BUILDING 2105 SOUTHSIDE SECOND FLOOR LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent (R)	190	4	J	0.00	748	$62	$702	$130	$16	$0	$146	$0.0	$0	$62	$702
2105	Range Opert Cent (R)	192	4	J	0.00	1,496	$124	$1,403	$130	$16	$0	$146	$0.0	$0	$124	$1,403
2105	Range Opert Cent	194	4	J	0.00	1,122	$93	$1,052	$130	$16	$0	$146	$0.0	$0	$93	$1,052
2105	Range Opert Cent	195	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	196	4	J	0.00	499	$41	$468	$130	$16	$0	$146	$0.0	$0	$41	$468
2105	Range Opert Cent	197	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	198	4	J	0.00	748	$62	$702	$130	$16	$0	$146	$0.0	$0	$62	$702
2105	Range Opert Cent	201	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	202	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	205	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent (R)	207	4	J	0.00	997	$83	$935	$130	$16	$0	$146	$0.0	$0	$83	$935
2105	Range Opert Cent	208	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	210	4	J	0.00	249	$21	$234	$130	$16	$0	$146	$0.0	$0	$21	$234
2105	Range Opert Cent	211	4	J	0.00	249	$21	$234	$130	$16	$0	$146	$0.0	$0	$21	$234
2105	Range Opert Cent	212	4	J	0.00	1,122	$93	$1,052	$130	$16	$0	$146	$0.0	$0	$93	$1,052
2105	Range Opert Cent	213	4	J	0.00	499	$41	$468	$130	$16	$0	$146	$0.0	$0	$41	$468
2105	Range Opert Cent	214	4	J	0.00	262	$22	$246	$130	$16	$0	$146	$0.0	$0	$22	$246
2105	Range Opert Cent	216	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	217	4	J	0.00	997	$83	$935	$130	$16	$0	$146	$0.0	$0	$83	$935
2105	Range Opert Cent	219	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	220	4	J	0.00	374	$31	$351	$130	$16	$0	$146	$0.0	$0	$31	$351
2105	Range Opert Cent	221	4	J	0.00	623	$52	$585	$130	$16	$0	$146	$0.0	$0	$52	$585
2105	Range Opert Cent	235	8	J	0.00	291	$24	$273	$130	$16	$0	$146	$0.0	$0	$24	$273
2105	Range Opert Cent	165/166/169	4	J3	0.00	1,995	$166	$1,871	$391	$47	$0	$437	$0.0	$0	$166	$1,871
Totals for Retrofit				J	0.00	26,125	$2,168	$24,503	$5,858	$703	$0	$6,561	$0	$0	$2,168	$24,503
													SIR	3.73	Payback	3.03
Totals for Building				I & J	0.00	51,470	$4,272	$48,274	$15,412	$1,849	$0	$17,261	$0	$0	$4,272	$48,274
													SIR	2.80	Payback	4.04
Not included (nic)																
2105	Range Opert Cent (R)	229A	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	229B	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	229C	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	234A	8	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	236B	8	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	150	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	151	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	152	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	153	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

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TABLE H-17 BUILDING 2105 SOUTHSIDE SECOND FLOOR LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
2105	Range Opert Cent	156	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	178	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	191	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	193	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	215	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	222	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	223	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	225	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	226	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	227	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	228	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	230	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	231	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	232	8	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
2105	Range Opert Cent	237	15	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

TOTAL BLDG (kWH/Yr)

TOTAL LOAD CONN

LIGHTING RETROFIT LEGEND
I. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Ceiling Mounted
J. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Automatic Wall Switch

Notes: APS states that occupancy sensors normally save about 25% (min) of lighting energy use. With little local switching available in this building, and limited occupancy in many offices, energy savings are assumed 33% for J type retrofits; I type retrofits are designated for larger areas, thus, 25% is used.

Range Opert Cent (R) indicates rooms where lighting retrofit evaluations resulted in SIR's > 1.0; these retrofits are assumed accomplished before occupancy sensors are installed.

LIGHTING LEDGEND

Task Code | Fixture Type

TABLE H-18 BUILDING 3482 LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
3482	Test Prep Facility	101	12	M	0.00	2,340	$194	$2,195	Included	Included	$0	Included	$0.0	$0	$194	$2,195
3482	Test Prep Facility	102	12	M	0.00	520	$43	$488	Included	Included	$0	Included	$0.0	$0	$43	$488
3482	Test Prep Facility	103	12	M	0.00	1,040	$86	$975	Included	Included	$0	Included	$0.0	$0	$86	$975
3482	Test Prep Facility	104	12	M	0.00	2,340	$194	$2,195	Included	Included	$0	Included	$0.0	$0	$194	$2,195
3482	Test Prep Facility	106	4	M	0.00	520	$43	$488	Included	Included	$0	Included	$0.0	$0	$43	$488
3482	Test Prep Facility	107	4	M	0.00	520	$43	$488	Included	Included	$0	Included	$0.0	$0	$43	$488
3482	Test Prep Facility	108	12	M	0.00	2,340	$194	$2,195	Included	Included	$0	Included	$0.0	$0	$194	$2,195
3482	Test Prep Facility	109	12	M	0.00	1,560	$129	$1,463	Included	Included	$0	Included	$0.0	$0	$129	$1,463
3482	Test Prep Facility	110	12	M	0.00	1,560	$129	$1,463	Included	Included	$0	Included	$0.0	$0	$129	$1,463
3482	Test Prep Facility	111	12	M	0.00	1,560	$129	$1,463	Included	Included	$0	Included	$0.0	$0	$129	$1,463
3482	Test Prep Facility	113	12	M	0.00	1,560	$129	$1,463	Included	Included	$0	Included	$0.0	$0	$129	$1,463
3482	Test Prep Facility	114	12	M	0.00	1,560	$129	$1,463	Included	Included	$0	Included	$0.0	$0	$129	$1,463
3482	Test Prep Facility	115	12	M	0.00	1,560	$129	$1,463	Included	Included	$0	Included	$0.0	$0	$129	$1,463
3482	Test Prep Facility	116	12	M	0.00	1,560	$129	$1,463	Included	Included	$0	Included	$0.0	$0	$129	$1,463
3482	Test Prep Facility	117	12	M	0.00	1,560	$129	$1,463	Included	Included	$0	Included	$0.0	$0	$129	$1,463
3482	Test Prep Facility	121	12	M	0.00	1,560	$129	$1,463	Included	Included	$0	Included	$0.0	$0	$129	$1,463
3482	Test Prep Facility	122	12	M	0.00	2,340	$194	$2,195	Included	Included	$0	Included	$0.0	$0	$194	$2,195
3482	Test Prep Facility	123	12	M	0.00	2,340	$194	$2,195	Included	Included	$0	Included	$0.0	$0	$194	$2,195
3482	Test Prep Facility	124	12	M	0.00	2,340	$194	$2,195	Included	Included	$0	Included	$0.0	$0	$194	$2,195
Totals for Retrofit				**M**	**0.00**	**30,680**	**$2,546**	**$28,775**	**$13,589**	**$1,631**	**$0**	**$15,220**	**$0.0**	**$0**	**$2,546**	**$28,775**
													SIR	**1.89**	**Payback**	**5.98**
3482	Test Prep Facility	105	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3482	Test Prep Facility	112	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3482	Test Prep Facility	118	8	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3482	Test Prep Facility	119	8	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3482	Test Prep Facility	120	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND **M. Install Light Switching for Assembly Rooms - Bldg 3482**

Notes: Presently, no rooms have dedicated switches. All lights are left on all day during working hours. Depending on activity level, most rooms are seldom entered. To be conservative, assumed that 50% of the lighting energy is saved in retrofit rooms.

TABLE H-19 BUILDING 3490 LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
3490	Weapon Eval Fac	14	8	I	0.00	83	$7	$78	$299	$36	$0	$334	$0.0	$0	$7	$78
3490	Weapon Eval Fac	15	8	I	0.00	374	$31	$351	$299	$36	$0	$334	$0.0	$0	$31	$351
3490	Weapon Eval Fac	23	8	I	0.00	125	$10	$117	$299	$36	$0	$334	$0.0	$0	$10	$117
3490	Weapon Eval Fac	27	4	I2	0.00	1,664	$138	$1,561	$597	$72	$0	$669	$0.0	$0	$138	$1,561
3490	Weapon Eval Fac (R)	32A	4	I	0.00	632	$52	$593	$299	$36	$0	$334	$0.0	$0	$52	$593
Totals for Retrofit				I	0.00	2,879	$239	$2,700	$1,791	$215	$0	$2,006	$0	$0	$239	$2,700
													SIR	1.35	Payback	8.40
3490	Weapon Eval Fac (R)	05	4	J	0.00	237	$20	$222	$130	$16	$0	$146	$0.0	$0	$20	$222
3490	Weapon Eval Fac (R)	06	4	J	0.00	316	$26	$297	$130	$16	$0	$146	$0.0	$0	$26	$297
3490	Weapon Eval Fac (R)	7.1	4	J	0.00	474	$39	$445	$130	$16	$0	$146	$0.0	$0	$39	$445
3490	Weapon Eval Fac (R)	7.2	4	J	0.00	316	$26	$297	$130	$16	$0	$146	$0.0	$0	$26	$297
3490	Weapon Eval Fac	13	8	J	0.00	125	$10	$117	$130	$16	$0	$146	$0.0	$0	$10	$117
3490	Weapon Eval Fac	16	8	J	0.00	166	$14	$156	$130	$16	$0	$146	$0.0	$0	$14	$156
3490	Weapon Eval Fac	17	8	J incl	0.00	42	$3	$39	included	included	$0	included	included	included	included	included
3490	Weapon Eval Fac (R)	20B	4	J	0.00	158	$13	$148	$130	$16	$0	$146	$0.0	$0	$13	$148
3490	Weapon Eval Fac	22	8	J	0.00	83	$7	$78	$130	$16	$0	$146	$0.0	$0	$7	$78
3490	Weapon Eval Fac	24	8	J	0.00	250	$21	$234	$130	$16	$0	$146	$0.0	$0	$21	$234
3490	Weapon Eval Fac	25	8	J	0.00	83	$7	$78	$130	$16	$0	$146	$0.0	$0	$7	$78
3490	Weapon Eval Fac	26	8	J incl	0.00	50	$4	$47	included	included	$0	included	included	included	included	included
3490	Weapon Eval Fac (R)	32B	4	J	0.00	316	$26	$297	$130	$16	$0	$146	$0.0	$0	$26	$297
3490	Weapon Eval Fac (R)	32C	4	J	0.00	316	$26	$297	$130	$16	$0	$146	$0.0	$0	$26	$297
3490	Weapon Eval Fac (R)	32D	4	J	0.00	316	$26	$297	$130	$16	$0	$146	$0.0	$0	$26	$297
Totals for Retrofit				J	0.00	3,249	$270	$3,047	$1,692	$203	$0	$1,895	$0	$0	$262	$2,961
													SIR	1.56	Payback	7.23
Totals for SIR > 1.0				I & J	0.00	6,128	$509	$5,747	$3,484	$418	$0	$3,902	$0	$0	$501	$5,661
													SIR	1.45	Payback	7.79
Not included (nic)																
3490	Weapon Eval Fac	01	11	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	02	11	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	03	11	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	04	11	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	08	3	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	09	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	20A	3	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	32E	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	10	1	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	11	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

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TABLE H-19 BUILDING 3490 LIGHTING CONTROLS RETROFIT EVALUATION

Bldg No	Building Name	Room No	Task Code	Retrofit Type	Demand (kW)	Electric (kW/Yr)	Power $ Saved ($/Yr)	Power $ Saved (LCC $)	Constr Cost	SIOH & Design	APS Rebate	Total Invest	O&M Saved/Yr	O&M LCC $ Saved	Total Cost Savings $/Year	Total Cost Savings $ LCC
3490	Weapon Eval Fac	12	8	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	18	10	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	19	15	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	21	14	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	28	11	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	29	11	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	30	10	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	31	10	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	32	10	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic
3490	Weapon Eval Fac	33	12	-	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic	nic

LIGHTING RETROFIT LEGEND

I. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Ceiling Mounted

J. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Automatic Wall Switch

CONSTRUCTION COST ESTIMATE					Date Prepared: January 1994		Sheet Of	
Project: EEAP Limited Energy Study					Project No.	Basis for Estimate: Code A (no design competed)		
Location: Yuma Proving Ground, Arizona								
Engineer-Architect: Keller & Gannon								
Drawing No.		Estimator: BIH				Checked By: RCL		

Line Item	Quantity No. Units	Quantity Unit Meas.	Labor * Per Unit	Labor * Total	Material Per Unit	Material Total	Total Cost
A. Retrofit Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp							
Electronic Ballast	1	EA	$21.98	$21.98	$25.00	$25.00	$46.98
32W-F32/T8 Lamp	1	EA	Included		$4.50	$4.50	$4.50
Subtotal				$21.98		$29.50	$51.48
State Sales Tax	5.5%	%		-		$1.62	$1.62
Subtotal							$53.10
Contractor OH & Profit	30.0%	%					$15.93
Subtotal							$69.03
Bond	1.0%	%					$0.69
Subtotal							$69.72
Estimating Contingency	10.0%	%					$6.97
Total Probable Construction Cost							$76.70
B. Retrofit Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps							
Electronic Ballast	1	EA	$21.98	$21.98	$25.00	$25.00	$46.98
32W-F32/T8 Lamp	2	EA	Included		$4.50	$9.00	$9.00
Subtotal				$21.98		$34.00	$55.98
State Sales Tax	5.5%	%		-		$1.87	$1.87
Subtotal							$57.85
Contractor OH & Profit	30.0%	%					$17.35
Subtotal							$75.20
Bond	1.0%	%					$0.75
Subtotal							$75.96
Estimating Contingency	10.0%	%					$7.60
Total Probable Construction Cost							$83.55
C. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps							
Electronic Ballast	1	EA	$22.82	$22.82	$31.00	$31.00	$53.82
32W-F32/T8 Lamp	3	EA	Included		$4.50	$13.50	$13.50
Subtotal				$22.82		$44.50	$67.32
State Sales Tax	5.5%	%		-		$2.45	$2.45
Subtotal							$69.77
Contractor OH & Profit	30.0%	%					$20.93
Subtotal							$90.70
Bond	1.0%	%					$0.91
Subtotal							$91.61
Estimating Contingency	10.0%	%					$9.16
Total Probable Construction Cost							$100.77

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CONSTRUCTION COST ESTIMATE

CONSTRUCTION COST ESTIMATE	Date Prepared: January 1994	Sheet Of	
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: Code A (no design competed)	
Location: Yuma Proving Ground, Arizona			
Engineer-Architect: Keller & Gannon			
Drawing No.	Estimator: BIH	Checked By: RCL	

Line Item	Quantity: No. Units	Quantity: Unit Meas.	Labor *: Per Unit	Labor *: Total	Material: Per Unit	Material: Total	Total Cost
D. Retrofit Unit Cost: 4-Lamp Electronic Ballast & T8 Lamps							
Electronic Ballast	2	EA	$21.98	$43.96	$25.00	$50.00	$93.96
32W-F32/T8 Lamp	4	EA	Included		$4.50	$18.00	$18.00
Subtotal				$43.96		$68.00	$111.96
State Sales Tax	5.5%	%		-		$3.74	$3.74
Subtotal							$115.70
Contractor OH & Profit	30.0%	%					$34.71
Subtotal							$150.41
Bond	1.0%	%					$1.50
Subtotal							$151.91
Estimating Contingency	10.0%	%					$15.19
Total Probable Construction Cost							$167.10
E. New Fixture Unit Cost: 1-Lamp Electronic Ballast & T8 Lamp							
Remove Existing Fixture	0.75	MH	$29.69	$22.40	-	-	$22.40
New Fixture: 1 x 32W-F32/T8 Lamp	1	EA	$44.80	$44.80	$125	$125.00	$169.80
Subtotal				$67.20		$125.00	$192.20
State Sales Tax	5.5%	%		-		$6.88	$6.88
Subtotal							$199.08
Contractor OH & Profit	30.0%	%					$59.72
Subtotal							$258.80
Bond	1.0%	%					$2.59
Subtotal							$261.39
Estimating Contingency	10.0%	%					$26.14
Total Probable Construction Cost							$287.53
F. New Fixture Unit Cost: 2-Lamp Electronic Ballast & T8 Lamps							
Remove Existing Fixture	0.8	MH	$29.69	$23.75	-	-	$23.75
New Fixture: 2 x 32W-F32/T8 Lamps	1	EA	$47.50	$47.50	$150	$150.00	$197.50
Subtotal				$71.25		$150.00	$221.25
State Sales Tax	5.5%	%		-		$8.25	$8.25
Subtotal							$229.50
Contractor OH & Profit	30.0%	%					$68.85
Subtotal							$298.36
Bond	1.0%	%					$2.98
Subtotal							$301.34
Estimating Contingency	10.0%	%					$30.13
Total Probable Construction Cost							$331.47

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CONSTRUCTION COST ESTIMATE

Date Prepared	January 1994
Sheet Of	
Project	EEAP Limited Energy Study
Project No.	
Basis for Estimate	Code A (no design competed)
Location	Yuma Proving Ground, Arizona
Engineer-Architect	Keller & Gannon
Drawing No.	
Estimator	BIH
Checked By	RCL

Line Item	Quantity		Labor *		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
G. New Fxtr Unit Cost: 3-Lamp Elect. Bal. & T8 Lamps - Explosion Proof							
Remove Existing Fixture	0.85	MH	$29.69	$25.27	-	-	$25.27
New Fixture: 3 x 32W-F32/T8 Lamps	1	EA	$87.87	$87.87	$1,675	$1,675	$1,762.87
Subtotal				$113.14		$1,675	$1,788.14
State Sales Tax	5.5%	%		-		$92.13	$92.13
Subtotal							$1,880.26
Contractor OH & Profit	30.0%	%					$564.08
Subtotal							$2,444.34
Bond	1.0%	%					$24.44
Subtotal							$2,468.79
Estimating Contingency	10.0%	%					$246.88
Total Probable Construction Cost							$2,715.67
H. Retrofit Unit Cost: 3-Lamp Electronic Ballast & T8 Lamps & Specular Reflector							
Electronic Ballast	1	EA	$22.82	$22.82	$31.00	$31.00	$53.82
32W-F32/T8 Lamp	3	EA	Included		$4.50	$13.50	$13.50
Specular Imaging Reflector	1	EA	$14.84	$14.84	$20.00	$20.00	$34.84
Subtotal				$37.67		$64.50	$102.17
State Sales Tax	5.5%	%		-		$3.55	$3.55
Subtotal							$105.72
Contractor OH & Profit	30.0%	%					$31.72
Subtotal							$137.43
Bond	1.0%	%					$1.37
Subtotal							$138.81
Estimating Contingency	10.0%	%					$13.88
Total Probable Construction Cost							$152.69
I. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Ceiling Mounted							
Ultrasonic Motion Sensor	1	EA	$22.62	$22.62	$86.00	$86.00	$108.62
Sensor Transformer Pack	1	EA	$15.80	$15.80	$30.00	$30.00	$45.80
Wiremold Raceway & 3/C #18 Wire	15	LF	$2.38	$35.63	$0.65	$9.75	$45.38
Subtotal				$74.04		$125.75	$199.79
State Sales Tax	5.5%	%		-		$6.92	$6.92
Subtotal							$206.71
Contractor OH & Profit	30.0%	%					$62.01
Subtotal							$268.72
Bond	1.0%	%					$2.69
Subtotal							$271.41
Estimating Contingency	10.0%	%					$27.14
Total Probable Construction Cost							$298.55

CONSTRUCTION COST ESTIMATE	Date Prepared: January 1994	Sheet Of
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: Code A (no design competed)
Location: Yuma Proving Ground, Arizona		
Engineer-Architect: Keller & Gannon		
Drawing No.	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Labor *		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
J. Retrofit Unit Cost: Occupancy Sensor Lighting Control - Automatic Wall Switch							
Automatic Wall Switch	1	EA	$22.62	$22.62	$64.00	$64.00	$86.62
Subtotal				$22.62		$64.00	$86.62
State Sales Tax	5.5%	%		-		$3.52	$3.52
Subtotal							$90.14
Contractor OH & Profit	30.0%	%					$27.04
Subtotal							$117.18
Bond	1.0%	%					$1.17
Subtotal							$118.35
Estimating Contingency	10.0%	%					$11.83
Total Probable Construction Cost							$130.18
K. New Fixture Unit Cost: 2-Lamp Compact Fluorescent 2 x 13W/5T4							
Remove Existing Fixture	0.75	MH	$29.69	$22.27	-	-	$22.27
New Fixture: 2 x 13W/5T4	1	EA	$43.80	$43.80	$45	$45.00	$88.80
Subtotal				$66.06		$45.00	$111.06
State Sales Tax	5.5%	%		-		$2.48	$2.48
Subtotal							$113.54
Contractor OH & Profit	30.0%	%					$34.06
Subtotal							$147.60
Bond	1.0%	%					$1.48
Subtotal							$149.08
Estimating Contingency	10.0%	%					$14.91
Total Probable Construction Cost							$163.99
L. New Fxtr Unit Cost: 2-Lamp Elect. Ballast & T8 Lamps, 2' Surface Mount							
Remove Existing Fixture	0.8	MH	$29.69	$23.75	-	-	$23.75
Fixture: 2 x 32W-F20/T8 Lamps 24"	1	EA	$49.88	$49.88	$175	$175.00	$224.88
Subtotal				$73.63		$175.00	$248.63
State Sales Tax	5.5%	%		-		$9.63	$9.63
Subtotal							$258.25
Contractor OH & Profit	30.0%	%					$77.48
Subtotal							$335.73
Bond	1.0%	%					$3.36
Subtotal							$339.09
Estimating Contingency	10.0%	%					$33.91
Total Probable Construction Cost							$373.00

* Labor rate based on Means '94 rate including subcontractor OH&P, adjusted for Yuma, AZ.

CONSTRUCTION COST ESTIMATE	Date Prepared: January 1994	Sheet Of
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: Code A (no design competed)
Location: Yuma Proving Ground, Arizona		
Engineer-Architect: Keller & Gannon		
Drawing No.	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Labor *		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
M. Install Light Switching for Assembly Rooms - Bldg 3482							
Expl Proof Switch: 2-way	2	EA	$44.80	$89.60	$69.00	$138.00	$227.60
Expl Proof Switch: 3-way	10	EA	$67	$672.02	$97.09	$970.93	$1,642.95
Expl Proof Switch: 4-way	3	EA	$110	$330.11	$148	$443.57	$773.68
Expl Proof Switch: 5-way	2	EA	$153	$305.74	$197	$394.29	$700.02
Junction Boxes	19	EA	$29.70	$564.38	$8.40	$159.60	$723.98
Conduit	925.1	LF	$2.45	$2,265.91	$0.93	$860.34	$3,126.25
Wiring 3 Ea #12 THWN	2775	LF	$0.32	$898.54	$0.20	$555.06	$1,453.60
Wiring #12 Bare Copper	925.1	LF	$0.27	$253.37	$0.06	$55.04	$308.41
Core thru 10" Conc Wall - 1" Dia	12	EA	$17.55	$210.56	$3.56	$42.72	$253.28
Subtotal				$5,590		$3,620	$9,210
State Sales Tax	5.5%	%		-		$199.08	$199.08
Subtotal							$9,408.84
Contractor OH & Profit	30.0%	%					$2,822.65
Subtotal							$12,231.49
Bond	1.0%	%					$122.31
Subtotal							$12,353.81
Estimating Contingency	10.0%	%					$1,235.38
Total Probable Construction Cost							$13,589.19

* Labor rate based on Means '94 rate including subcontractor OH&P, adjusted for Yuma, AZ.

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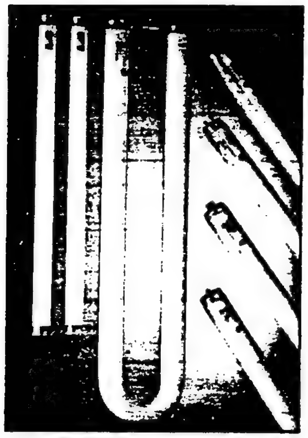
Lighting, Lamps, Ballasts and Photoelectric Controls
Fluorescent Lamps
Philips



Advantage X Fluorescent Lamps

These lamps combine two technologies developed by Philips Lighting—the use of a smaller diameter T-10 envelope and a unique new blend of three rare earth activated phosphors. At 3700 lumens produces 21% more light than an F40CW lamp. With a rated average life of 24,000 hours, it will last 20% longer on average than any other 4-foot fluorescent lamp made.

Spec Line Fluorescent Lamps

Improved color rendering, preheat rapid start HO and Slimline in three colors, standard and energy saving wattages, straight and U-bent. Employs a thin coat of trichromatic phosphors over a base coat of standard phosphors—thus, these lamps offer higher lumen output and better color rendering than standard lamps.

Ultralume Standard And Energy-saving Lamps

Contain rare-earth activated three component phosphors to provide excellent color rendering properties and high luminous efficacy. Selection of Ultralume lamps is primarily a matter of taste, whether one prefers warm illumination or cool illumination. All five Ultralume types provide the highest levels of visual clarity.

Selection Guide

WESCO Stock No.	Watts	Lamp Type	Description	Bulb	Base	Rated Avg. Life (Hrs.)	Approx. Initial Lumens	Nominal Length Inches	Ship Case Qty.	List	WESCO Each
Advantage X Fluorescent Lamps											
04-6677-25119	40	F40/AX30	3000K Advantage X	T10	Md. Bipin	24000	3700	48	30	$12.82	$11.54
04-6677-24992	40	F40/AX35	3500K Advantage X	T10	Md. Bipin	24000	3700	48	30	12.82	11.31
04-6677-24996	40	F40/AX41	4100K Advantage X	T10	Md. Bipin	24000	3700	48	30	12.82	11.31
04-6677-30133	40	F40/AX50	5000K Advantage X	T10	Md. Bipin	24000	3700	48	30	12.82	11.31
Spec Line Standard & Energy-saving Fluorescent Lamps											
04-6677-31371	30	F30/T12/SPEC35/RS	3500K SPEC	T12	Md. Bipin	18000	2350	36	30	10.32	9.29
04-6677-31553	34	F40SPEC30/RS/EW-II	3000K SPEC	T12	Md. Bipin	20000	2800	48	30	6.31	5.68
04-6677-37992	34	F40/SPEC35/RS/EW-II	3500K SPEC(214)	T12	Md. Bipin	20000	2800	48	30	6.31	5.01
04-6677-31546	34	F40SPEC41/RS/EW-II	4100K SPEC(214)	T12	Md. Bipin	20000	2800	48	30	6.31	5.01
04-6677-27251	40	F40/SPEC30	3000K SPEC	T12	Md. Bipin	20000	3200	48	30	6.03	5.43
04-6677-22116	40	F40/SPEC35	3500K SPEC	T12	Md. Bipin	20000	3200	48	30	5.44	4.09
04-6677-23706	40	FB40/SPEC35/6	3500K SPEC(212)	T12	Md. Bipin	18000	3050	22⁷⁄₁₆	12	15.40	13.86
04-6677-27258	40	F40/SPEC41	4100K SPEC	T12	Md. Bipin	20000	3200	48	30	6.03	5.43
04-6677-34846	60	F96T12/SPEC30/EW	3000K SPEC(214)	T12	Single Pin	12000	5750	96	15	14.99	13.49
04-6677-37998	60	F96T12/SPEC35/EW	3500K SPEC(214)	T12	Single Pin	12000	5750	96	15	13.52	12.17
04-6677-34844	60	F96T12/SPEC41/EW	4100K SPEC(214)	T12	Single Pin	12000	5750	96	15	13.52	12.17
04-6677-27262	75	F96T12/SPEC30	3000K SPEC	T12	Single Pin	12000	6300	96	15	14.31	12.88
04-6677-22118	75	F96T12/SPEC35	3500K SPEC	T12	Single Pin	12000	6425	96	15	12.91	11.62
04-6677-27265	75	F96T12/SPEC41	4100K SPEC	T12	Single Pin	12000	6425	96	15	13.56	12.20
04-6677-34861	95	F96T12/SPEC30/HO/EW	3000K SPEC(207)(214)	T12	Rec. D.C.	12000	8350	96	15	15.53	13.98
04-6677-22117	95	F96T12/SPEC35/HO/EW	3500K SPEC(207)(214)	T12	Rec. D.C.	12000	8350	96	15	15.53	13.98
04-6677-34848	95	F96T12/SPEC41/HO/EW	4100K SPEC(207)(214)	T12	Rec. D.C.	1200	8350	96	15	15.53	13.98
Ultralume Standard and Energy-saving Fluorescent Lamps											
04-6677-35581	13	F13T5/27U	2700K ULTRALUME	T5	Min. Bipin	7500	1000	21	25	16.43	14.79
04-6677-31532	34	F40/30U/RS/EW-II	3000K ULTRALUME(214)	T12	Md. Bipin	20000	2900	48	30	11.51	10.36
04-6677-38004	34	F40/35U/RS/EW-II	3500K ULTRALUME(214)	T12	Md. Bipin	20000	2900	48	30	11.51	10.36
04-6677-31533	34	F40/41U/RS/EW-II	4100K ULTRALUME(214)	T12	Md. Bipin	20000	2900	48	30	6.31	5.68
04-6677-31535	34	F40/50U/RS/EW-II	5000K ULTRALUME(214)	T12	Md. Bipin	20000	2880	48	30	13.00	11.70
04-6677-35449	40	FB40/30U/6	3000K ULTRALUME(212)	T12	Md. Bipin	18000	3100	22⁷⁄₁₆	12	18.44	16.60
04-6677-22124	40	FB40/35U/6	3500K ULTRALUME(212)	T12	Md. Bipin	18000	3100	22⁷⁄₁₆	12	20.44	18.40
04-6677-31537	40	F40/30U	3000K ULTRALUME	T12	Md. Bipin	20000	3300	48	30	11.07	8.78
04-6677-38003	40	F40/35U	3500K ULTRALUME	T12	Md. Bipin	20000	3300	48	30	11.07	9.96
04-6677-31538	40	F40/41U	4100K ULTRALUME	T12	Md. Bipin	20000	3300	48	30	12.27	11.04
04-6677-31539	40	F40/50U	5000K ULTRALUME	T12	Md. Bipin	20000	3280	48	30	12.49	11.24
04-6677-34205	60	F96T12/30U/EW	3000K ULTRALUME(214)	T12	Single Pin	12000	5900	96	15	24.17	21.75
04-6677-3[illegible]	75	F96T12/30U	3000K ULTRALUME	T12	Single Pin	12000	6600	96	15	23.41	21.07

High Color Rendering Fluorescent Interchange Guide

Philips	CRI	Sylvania	CRI	G.E.	CRI
Spec Line	70-73	Design Line	70-73	SP Line	70-73
TL 70	75	Octron	75	Trimline75	75
Advantage X	80	None	—	Staybright XL	82
Ultralume	85	Designer 800 Series	82	SPX	82
TL 80	85	None	—	None	—
Colortone 50	92	None	—	Chroma 50	90
Colortone 75	95	None	—	Chroma 75	92

WESCO
the extra
effort people

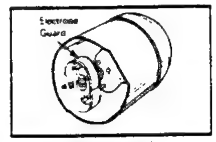
Lighting, Lamps, Ballasts and Photoelectric Controls
Fluorescent Lamps
Philips

TL70 and TL80 Fluorescent Lamps

TL70 and TL80 lamps are available in four wattages (17, 25, 32, and 40), four lengths (2, 3, 4, 5 inches) and three color temperatures (3000K, 3500K and 4100K). Ideal applications include office buildings, retail stores, schools, and hospitals. TL70 and TL80 lamps are thin 1-inch diameter (T-8) tubes, which are to be operated on T-8 rapid start or electronic ballasts.

TL70 features:
- Provide a color rendering index of 75
- Provide efficiencies up to 91 lumens per watt on magnetic ballasts and over 97 lumens per watt on electronic ballasts

TL80 features:
- Provide a color rendering index of 85
- Up to 43% savings in energy costs when installed with electronic ballasts compared to standard T-12 fluorescent lamps with standard magnetic ballasts
- Lower energy costs when installed with electronic ballasts compared to energy-saving lamps on standard ballasts



Electrode Guard
For maximum lumen maintenance TL70 and TL80 lamps feature an "electrode guard" around each electrode to effectively reduce lamp darkening and retain a clean appearance for thousands of hours.

Selection Guide

WESCO Stock No.	Watts	Lamp Type	Description	Bulb	Base	Rated Avg. Life (Hrs.)	Approx. Initial Lumens	Nominal Length (Inches)	Kelvin Color Temp.	Color Rend Index	Ship Case Qty.	List	WESCO Each
TL70 Fluorescent Lamps													
04-6677-32061	17	F17T8/TL730	3000K TL70	T8	Md. Bipin	20.000	1325	24	3000	75	25	$6.96	$6.26
04-6677-32297	17	F17T8/TL735	3500K TL70	T8	Md. Bipin	20.000	1325	24	3500	75	25	6.96	6.26
04-6677-32062	17	F17T8/TL741	4100K TL70	T8	Md. Bipin	20.000	1325	24	4100	75	25	6.96	6.26
04-6677-32050	25	F25T8/TL730	3000K TL70	T8	Md. Bipin	20.000	2125	36	3000	75	25	6.96	6.26
04-6677-32298	25	F25T8/TL735	3500K TL70	T8	Md. Bipin	20.000	2125	36	3500	75	25	6.96	6.26
04-6677-32051	25	F25T8/TL741	4100K TL70	T8	Md. Bipin	20.000	2125	36	4100	75	25	6.96	6.26
04-6677-32052	32	F32T8/TL730	3000K TL70	T8	Md. Bipin	20.000	2850	48	3000	75	25	5.17	4.56
04-6677-32054	32	F32T8/TL735	3500K TL70	T8	Md. Bipin	20.000	2850	48	3500	75	25	5.17	4.56
04-6677-32055	32	F32T8/TL741	4100K TL70	T8	Md. Bipin	20.000	2850	48	4100	75	25	5.17	4.56
04-6677-32057	40	F40T8/TL730	3000K TL70	T8	Md. Bipin	20.000	3600	60	3000	75	25	7.06	6.35
04-6677-32301	40	F40T8/TL735	3500K TL70	T8	Md. Bipin	20.000	3600	60	3500	75	25	7.06	6.35
04-6677-32058	40	F40T8/TL741	4100K TL70	T8	Md. Bipin	20.000	3600	60	4100	75	25	7.06	6.35
TL80 Fluorescent Lamps													
04-6677-31980	17	F17T8/TL830	3000K TL80	T8	Md. Bipin	20.000	1400	24	3000	85	25	9.81	8.83
04-6677-32304	17	F17T8/TL835	3500K TL80	T8	Md. Bipin	20.000	1400	24	3500	85	25	9.81	8.83
04-6677-31983	17	F17T8/TL841	4100K TL80	T8	Md. Bipin	20.000	1400	24	4100	85	25	9.81	8.83
04-6677-31984	25	F25T8/TL830	3000K TL80	T8	Md. Bipin	20.000	2250	36	3000	85	25	9.81	8.83
04-6677-25798	25	F25T8/TL835	3500K TL80	T8	Md. Bipin	20.000	2250	36	3500	85	25	9.81	8.83
04-6677-31989	25	F25T8/TL841	4100K TL80	T8	Md. Bipin	20.000	2250	36	4100	85	25	9.81	8.83
04-6677-31991	32	F32T8/TL830	3000K TL80	T8	Md. Bipin	20.000	3050	48	3000	85	25	8.42	7.58
04-6677-31993	32	F32T8/TL835	3500K TL80	T8	Md. Bipin	20.000	3050	48	3500	85	25	8.42	7.43
04-6677-31994	32	F32T8/TL841	4100K TL80	T8	Md. Bipin	20.000	3050	48	4100	85	25	8.42	7.43
04-6677-31996	40	F40T8/TL830	3000K TL80	T8	Md. Bipin	20.000	3800	60	3000	85	25	9.98	8.98
04-6677-25799	40	F40T8/TL835	3500K TL80	T8	Md. Bipin	20.000	3800	60	3500	85	25	9.98	8.98
04-6677-31998	40	F40T8/TL841	4100K TL80	T8	Md. Bipin	20.000	3800	60	4100	85	25	9.98	8.98

Fluorescent Lamp Performance Comparisons

Features	TL80	Advantage X	TL70	Ultralume	SPEC
Lumens per Watt	95[2]	93	89	83	80
Energy Efficiency	25%	21%	17%	8%	5%
CRI	85	80	75	85	70-73
Color Temp. Range Available	3000K-4100K	3000K-5000K	3000K-4100K	2700K-5000K	3000K-4100K
Lumens Output	3050	3700	2850	3300	3200
Life Expectancy (hours)	20.000	24.000	20.000	20,000	20,000
Key End Use Needs	Highest energy savings with highest color rendering	Highest light output; high energy savings	Achieve good energy savings with good light output and quality	High color rendering and good light output	Achieve good light output and quality
Recommended Applications	General, private office showrooms, department stores, classrooms	General office, department store, jewelry stores, schoolrooms, corridors, libraries	General office, pharmacies, corridors, libraries	Hotel rooms, boutiques, jewelry stores, galleries hospital examining and emergency areas, nurseries	General office, pharmacies, corridors, libraries

[1] Energy efficiency compared to 40-watt cool white fluorescents
[2] 104 LPW when operated on a High Frequency Ballast

Prices subject to change without notice

UNIVESAL → $27 , $28.50
621-1888 * B&K ELECT
626-1122

ADVANCE®
Mark V
Electronic
Integrated Circuit
Ballasts

For Rapid Start Lamps

ADVANCE
TRANSFORMER CO.
A DIVISION OF NORTH AMERICAN PHILIPS CORPORATION

ADVANCE® Mark V Electronic Ballast Characteristics

Lamp Operation and Performance

The ADVANCE Mark V is an electronic integrated circuit ballast that operates a wide range of rapid start fluorescent lamps with outstanding stability and reliability.

The Mark V design incorporates a silicon chip "brain" that maintains constant light output through input voltage variations of as much as ±25%. The result is stable lighting with no distracting flicker or light loss, despite "brownouts" or other irregularities in input voltage.

The Mark V design also has an average crest factor below 1.4, minimal total harmonic distortion content (see accompanying table), and maintains continuous heating of lamp electrodes for longest lamp life.

The Mark V runs 30°C cooler than conventional electromagnetic ballasts for longer life; and is ha the weight of electromagnetics.

Energy Efficiency

The high frequency operation of the Mark V electronic ballast provides greatest lamp efficiencies-26% more energy efficient at full light output thar conventional electromagnetic ballasts.

Silent Operation

ADVANCE Mark V electronic ballasts, because they *do not* incorporate laminate core and coil componentry, have a super-quiet operating sounc level—only 2dB above a 16dB ambient (typical).

Specifications

1. Ballast shall be UL listed (Class P) and CSA certified.
2. Ballast sound levels shall not exceed Class A ambient noise levels.
3. Ballast shall maintain constant light output of all Rapid Start Fluorescent Lamps over operating ranges of 90V to 145V (120V ballasts) and 200V to 320V (277V ballasts).
4. Input current Total Harmonic Distortion content shall be below or within ranges shown in accompanying table (expressed in percentage of full light output current level).
5. Ballast shall have an average lamp current crest factor below 1.4.
6. Where applicable, ballasts shall meet minimum efficacy standards of Public Law No. 100-357, National Appliance Energy Conservation Amendments of 1988.
7. Ballast shall have a sequenced start progression which first heats cathode filaments and then ignites the lamp.
8. Ballast shall withstand line transients as defined in ANSI/IEEE C62.41, Category A.
9. Ballast case temperature shall not exceed 25°C temperature rise over 40°C ambient.
10. Ballast shall have a frequency of operation of 20 KHz or greater, and operate without visible flicker.
11. Ballast shall have a power factor of 90% or above.
12. Ballast shall not contain polychlorinated biphenyls (PCB's).
13. Ballast shall meet the requirements of the Federal Communications Commission Rules and Regulations, Part 18, Class A.

ADVANCE® Mark V Electronic Integrated Circuit Ballasts

Lamp Data: No.	Type	Watts	Min. Start Temp. (°F)	Circuit (Volts)	Catalog Number	Input Watts (ANSI)	Line Current (AMPS)	Average Ballast Factor (ANSI)	Percent Total Harmonic Distortion (ANSI)	Sound Rating	Wir. Dia. Fig.	Wt. Ea. (Lbs.)
1	F25T8	25	50	120	RIC-132-TP	24	.21	.800-.849	< 10	A	1	1.5
					RIC-140-TP	34	.29	1.300				
				277	VIC-132-TP	24	.09	.800-.849	10-15			
					VIC-140-TP	34	.13	1.200				
2	F25T8	25	50	120	RIC-2S32-TP	44	.38	.800-.849	< 10	A	2	1.5
					RIC-2S40-TP	67	.57	1.300				
				277	VIC-2S32-TP	44	.17	.800-.849	10-15			
					VIC-2S40-TP	67	.25	1.200				
3	F25T8	25	50	120	RIC-3S32-TP	68	.58	.850-.924	< 10	A	3	2.5
				277	VIC-3S32-TP	66	.25					
1	F30T12	25	60	120	RIC-140-TP	28	.24	.925-1.000	< 10	A	1	1.5
		30	50			32	.27					
		25	60	277	VIC-140-TP	28	.10	.925-1.000	10-15			
		30	50			32	.12					
2	F30T12	25	60	120	RIC-2S40-TP	53	.45	.925-1.000	< 10	A	2	1.5
		30	50			62	.52					
		25	60	277	VIC-2S40-TP	53	.20	.925-1.000	10-15			
		30	50			62	.23					
3	F30T12	25	60	120	RIC-3S40-TP	84	.72	.850-.924	< 10	A	3	2.5
		30	50			92	.79					
		25	60	277	VIC-3S40-TP	82	.30	.850-.924	10-15			
		30	50			90	.33					
1	F32T8	32	50	120	RIC-132-TP	31	.27	.850-.924	< 10	A	1	1.5
					RIC-140-TP	40	.35	1.100				
				277	VIC-132-TP	31	.12	.850-.924	10-15			
					VIC-140-TP	40	.15	1.100				
2	F32T8	32	50	120	RIC-2S32-TP	61	.52	.850-.924	< 10	A	2	1.5
					RIC-2S40-TP	78	.67	1.100				
				277	VIC-2S32-TP	60	.22	.850-.924	10-15			
					VIC-2S40-TP	76	.28	1.100				
3	F32T8	32	50	120	RIC-3S32-TP	95	.82	.850-.924	< 10	A	3	2.5
				277	VIC-3S32-TP	93	.34					
1	PL-36 or Dulux L-36 or F39BX	36 36 39	50	120	RIC-140-TP	37	.31	.850-.924	< 10	A	4	1.5
				277	VIC-140-TP	37	.14		10-15			
2	PL-36 or Dulux L-36 or F39BX	36 36 39	50	120	RIC-2S40-TP	72	.61		< 10	A	5	1.5
				277	VIC-2S40-TP	70	.26		10-15			
3	PL-36 or Dulux L-36 or F39BX	36 36 39	50	120	RIC-3S40-TP	106	.90		< 10	A	6	2.5
				277	VIC-3S40-TP	104	.38		10-15			
1	F40BX or PL-40	40	50	120	RIC-132-TP	37	.31	.850-.924	< 10	A	4	1.5
				277	VIC-132-TP	37	.14		10-15			
2	F40BX or PL-40	40	50	120	RIC-2S32-TP	72	.62		< 10	A	5	1.5
				277	VIC-2S32-TP	71	.26		10-15			
1	F40T10	40	50	120	RIC-140-TP	37	.31	.800-.849	< 10	A	1	1.5
				277	VIC-140-TP	37	.14		10-15			
2	F40T10	40	50	120	RIC-2S40-TP	73	.62	.800-.849	< 10	A	2	1.5
				277	VIC-2S40-TP	73	.27		10-15			
3	F40T10	40	50	120	RIC-3S40-TP	110	.94	.850-.924	< 10	A	3	2.5
				277	VIC-3S40-TP	108	.40		10-15			
1	F40T12	34	60	120	RIC-140-TPⒺ	31	.26	.850-.924	< 10	A	1	1.5
		40	50			36	.30					
		34	60	277	VIC-140-TPⒺ	31	.12		10-15			
		40	50			36	.14					
2	F40T12	34	60	120	RIC-2S40-TPⒺ	60	.51		< 10	A	2	1.5
		40	50			72	.61					
		34	60	277	VIC-2S40-TPⒺ	60	.23		10-15			
		40	50			72	.26					
3	F40T12	34	60	120	RIC-3S40-TP	95	.81		< 10	A	3	2.5
		40	50			106	.91					
		34	60	277	VIC-3S40-TP	93	.34		10-15			
		40	50			104	.38					

Ⓔ Meets or exceeds requirements of National Energy Conservation Amendments (NAECA) of 1988.

ADVANCE® Mark V Electronic Ballasts

Wiring Diagrams

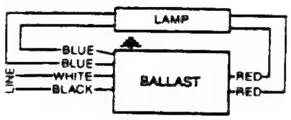


Figure 1

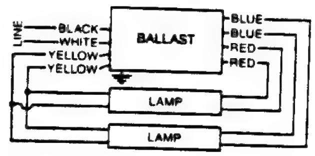


Figure 2

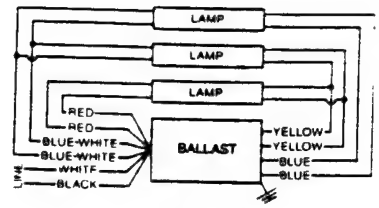


Figure 3

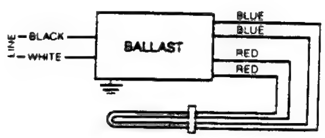


Figure 4

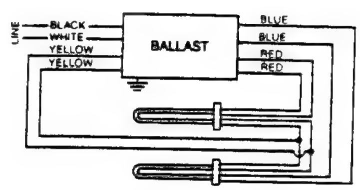


Figure 5

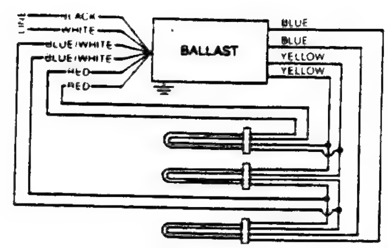
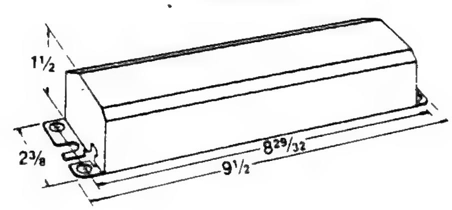


Figure 6

Dimensions



Specifications and data in this bulletin are subject to change without notice.

Leadership in Innovation

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Form No. 1535 Rev. 2/92 Printed in :

MagneTek

Lamp Type	No. of Lamps	Line Voltage	Catalog Number	Input Watts Std. Lamps FIXT	Input Watts Std. Lamps ANSI	Input Watts E.S. Lamps FIXT	Input Watts E.S. Lamps ANSI	Line Amps Nom.	Line Amps Max.	Min. Start. Temp.	Wiring Diag. Pages 9 & 10	Notes
OCTIC For use with OCTIC type (265 mA) T8 lamps, 2 to 5 feet in length..												
F017T8 (2' or U) (17 watt)	2	120	B232I120	32	34			.30	.34	0°F	8	a,b
		277	B232I277					.13	.15			
	3	120	B332I120	48	50			.45	.50	0°F	9	a,b
		277	B332I277					.19	.21			
	4	120	B432I120	60	62			.56	.63	50°F	10	a,b
		277	B432I277					.24	.27			
F025T8 (3' or U) (25 watt)	1	120	B232I120	29	30			.27	.30	0°F	7	a,b
		277	B232I277					.12	.13			
	2	120	B232I120	46	48			.43	.48	0°F	8	a,b
		277	B232I277					.19	.21			
	3	120	B332I120	66	68			.61	.68	0°F	9	a,b
		277	B332I277					.26	.29			
	4	120	B432I120	87	90			.81	.91	50°F	10	a,b
		277	B432I277					.35	.39			
F032T8 (4' or U) (32 watts)	1	120	B232I120	37	39			.34	.38	0°F	7	a,b
		277	B232I277					.15	.17			
	2	120	B232I120	58	62			.54	.60	0°F	8	a,b
		277	B232I277					.24	.27			
	3	120	B332I120	86	89			.78	.87	0°F	9	a,b
		277	B332I277					.34	.38			
	4	120	B432I120	109	114			1.00	1.12	50°F	10	a,b
		277	B432I277					.43	.48			
F040T8 (5') (40 watts)	1	120	B232I120	42	44			.39	.44	0°F	7	a,b
		277	B232I277					.17	.19			
	2	120	B232I120	69	73			.64	.72	0°F	8	a,b
		277	B232I277					.28	.31			
	3	120	B332I120	104	108			.95	1.06	0°F	9	a,b
		277	B332I277					.41	.46			
COMPACT For use with 18 to 40 watt biaxial compact lamps.												
F18BX (18 watts)	2	120	B232I120	34	35			.31	.35	50°F	12	a,b,i
		277	B232I277					.14	.16			
	3	120	B332I120	50	51			.46	.52	50°F	13	a,b,i
		277	B332I277					.20	.22			
F27BX (27 watt)	2	120	B232I120	40	41			.36	.40	50°F	12	a,b,i
		277	B232I277					.16	.18			
	3	120	B332I120	60	61			.54	.60	50°F	13	a,b,i
		277	B332I277					.23	.26			
F39BX (39 watt)	2	120	B232I120	51	52			.46	.52	50°F	12	a,b,e,i
		277	B232I277					.20	.22			
	3	120	B332I120	76	77			.68	.76	50°F	13	a,b,e,i
		277	B332I277					.29	.32			
F40BX (39 watt)	1	120	B232I120	41	43			.39	.43	50°F	11	a,b,i
		277	B232I277					.17	.19			
	2	120	B232I120	70	72			.63	.70	50°F	12	a,b,i
		277	B232I277					.27	.30			
	3	120	B332I120	103	105			.92	1.03	50°F	13	a,b,i
		277	B332I277					.40	.45			

Notes:

a. Parallel lamp connections allow remaining lamps to stay fully lit if companion lamps fail.

b. CSA (Canadian Standard Asociation) certified (120 volt model only).

e. This lamp/ballast combination yields approximately 70% light output due to difference in lamp current rating. All others in this family yield full light output or more.

i. Consult factory for information regarding other compact types (18 to 40 watt).

Lamp Type	No. of Lamps	Line Voltage	Catalog Number	Input Watts Std. Lamps FIXT*	Input Watts Std. Lamps ANSI*	Input Watts E.S. Lamps FIXT	Input Watts E.S. Lamps ANSI	Line Amps Nom.	Line Amps Max.	Min. Start. Temp.	Wiring Diag. Page 10	Notes
LLSS SERIES RAPID START For use with T10 or T12, rapid start lamps 3 or 4 feet in length.												
F30T12 (3' or U) (30 watt)	1	120	B140T120S	16 / 27	16 / 29			.26	.29	50°F	14	g
		277	B140T277S					.11	.12			
	2	120	B240T120S	31 / 56	31 / 58			.52	.58	50°F	15	g
		277	B240T277S					.23	.26			
	3	120	B340T120S	47 / 81	48 / 85			.76	.85	50°F	16	g
		277	B340T277S					.33	.37			
F40T12 (4' or U) (40 watt)	1	120	B140T120S	20 / 35	20 / 37			.32	.36	50°F	14	g
		277	B140T277S					.14	.16			
	2	120	B240T120S	37 / 64	37 / 69			.61	.68	50°F	15	g
		277	B240T277S					.26	.29			
	3	120	B340T120S	58 / 97	59 / 103			.90	1.01	50°F	16	g
		277	B340T277S					.39	.44			
F40T10 (4') (40 watt)	1	120	B140T120S	22 / 37	22 / 39			.34	.38	50°F	14	g
		277	B140T277S					.15	.17			
	2	120	B240T120S	40 / 67	40 / 72			.63	.71	50°F	15	g
		277	B240T277S					.27	.30			
	3	120	B340T120S	63 / 102	64 / 108			.95	1.06	50°F	16	g
		277	B340T277S					.41	.46			
LLSS OCTIC For use with OCTIC type (265 mA), T8 lamps 3 or 4 feet in length.												
F025T8 (3' or U) (25 watt)	1	120	B132T120S	16 / 27	18 / 30			.27	.30	50°F	14	
		277	B132T277S					.12	.13			
	2	120	B232T120S	32 / 53	34 / 56			.50	.56	50°F	15	
		277	B232T277S					.22	.25			
F032T8 (4' or U) (32 watt)	1	120	B132T120S	19 / 33	21 / 36			.32	.36	50°F	14	
		277	B132T277S					.14	.16			
	2	120	B232T120S	36 / 63	38 / 65			.57	.63	50°F	15	
		277	B232T277S					.25	.28			

Note:
g. Not recommended for use with energy saving (32 or 34 watt, T12) lamps.

Key: * low level / high level

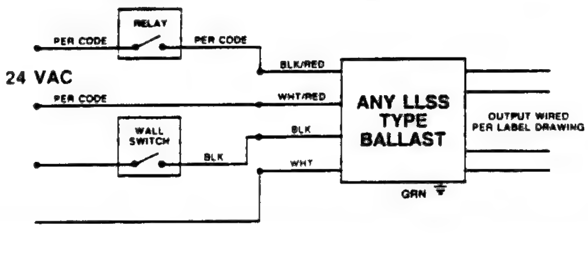
Light Level Switching Systems (LLSS) Technical Information

The LLSS concept allows a light level to be controlled by anything that can act as a voltage switch, including a simple wall switch, a low-voltage (24 VAC) energy management system, an occupancy sensor or a photocell (consult sensor manufacturer for specific application criteria).

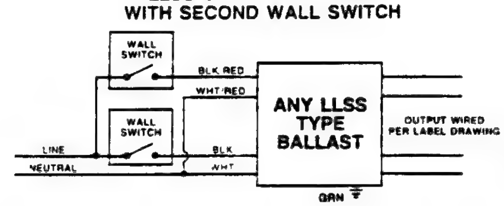
The distinction between 100% and 50% operation is achieved through two "control" leads at the input of the ballast.

When line voltage is applied between the black and white "line" leads, the ballast is energized, but it produces only half the normal light output. If the "control" leads (black/red and white/red) sense a voltage (24 volts up to the rated line voltage), the ballast automatically switches to full light output until that voltage is removed. Only 10 milliamps per ballast are required to activate the switch, so an entire bank of ballasts can be controlled by one device.

LLSS WITH 24 VAC MANAGEMENT SYSTEM



LLSS ON LINE VOLTAGE WITH SECOND WALL SWITCH



DEC 14 '93 14:10 DZ-COOK 1 415 282-3296 P.1

Attn: Don

DATE REC'D: 12/14/93

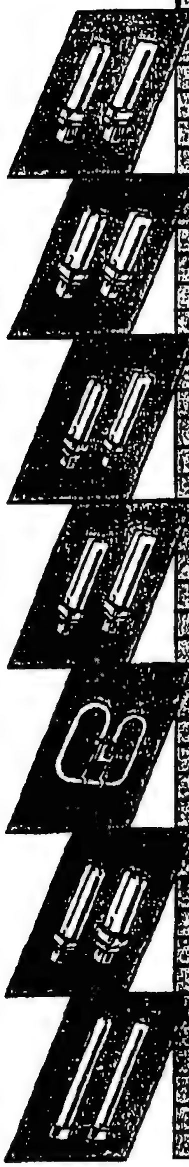
TIME REC'D: 2:30 pm

Compact Fluorescent Reference Chart

PROJECT No.:

ORIGINAL: ________ /FILE ________

COPY: Tmp



ANSI LAMP DESIGNATION	NEMA LAMP DESIGNATION	BUILT-IN STARTER	GE	OSRAM	OSRAM SYLVANIA	PANASONIC	PHILIPS
[illegible]	[illegible]	YES	F5 BX	DULUX-S 5	F5 TT	—	PL-S 5W
[illegible]	[illegible]	YES	F7 BX	DULUX-S 7	F7 TT	—	PL-S 7W
[illegible]	[illegible]	YES	F9 BX	DULUX-S 9	F9 TT	—	PL-S 9W
[illegible]	[illegible]	YES	F13 BX	DULUX-S 13	F13 TT	—	PL-S 13W
[illegible]	[illegible]	YES	—	DOUBLE DULUX 9	F9 DTT	—	—
[illegible]	[illegible]	YES	—	DOUBLE DULUX 13	F13 DTT	—	PL-C 13W/USA
[illegible]	[illegible]	YES	—	DULUX-D 10	—	—	—
[illegible]	[illegible]	YES	F12 DBX T4	DULUX-D 13	—	—	PL-C 13W
[illegible]	[illegible]	YES	F18 DBX T4	DULUX-D 18	F18 DTT	—	PL-C 18W
[illegible]	[illegible]	YES	F26 DBX T4	DULUX-D 26	F26 DTT	—	PL-C 26W
[illegible]	[illegible]	NO	—	DULUX-D/E 10	—	—	—
[illegible]	[illegible]	NO	—	DULUX-D/E 13	—	—	PL-C 13W/4P
[illegible]	[illegible]	NO	—	DULUX-D/E 18	—	—	PL-C 18W/4P
[illegible]	[illegible]	NO	—	DULUX-D/E 26	—	—	PL-C 26W/4P
[illegible]	[illegible]	NO	F10 2D	—	—	—	—
[illegible]	[illegible]	YES	F16 2D	—	—	—	—
[illegible]	[illegible]	NO	F21 2D	—	—	—	—
[illegible]	[illegible]	YES	F28 2D	—	—	—	—
[illegible]	[illegible]	NO	F38 2D	—	—	—	—
[illegible]	[illegible]	YES	—	—	—	FDL-18	—
[illegible]	[illegible]	YES	—	—	—	FDL-22	PL-C 18/M/22W
[illegible]	[illegible]	YES	—	—	—	FDL-27	PL-C 18/M/28W
[illegible]	[illegible]	NO	F18 BX	DULUX-L 18/19	—	—	PL-L 18
[illegible]	[illegible]	NO	F18 BX/RS	DULUX-L 18/10.5	—	—	—
[illegible]	[illegible]	NO	F27 BX	DULUX-L 24	—	—	PL-L 24
[illegible]	[illegible]	NO	F39 BX	DULUX-L 36	—	—	PL-L 36
[illegible]	[illegible]	NO	F40 BX	DULUX-L 40	—	—	PL-L 40

How to read this catalog:

ANSI Lamp Designation

Example: 26W / 8T4 / Q / G24d-3 / PH

A B C D E

- **A** Lamp Wattage (26 watts in example).
- **B** Lamp Length and Tube Diameter (First number = lamp length in inches; number following "T" = tube diameter in 1/8". Example: Lamp is 8" long with 1/2" tubes).
- **C** Lamp Configuration (T = twin tube, Q = quad tube).
- **D** Lamp Base Type.
- **E** Lamp Circuit (RS = Rapid Start, PH = Preheat).

R=96%

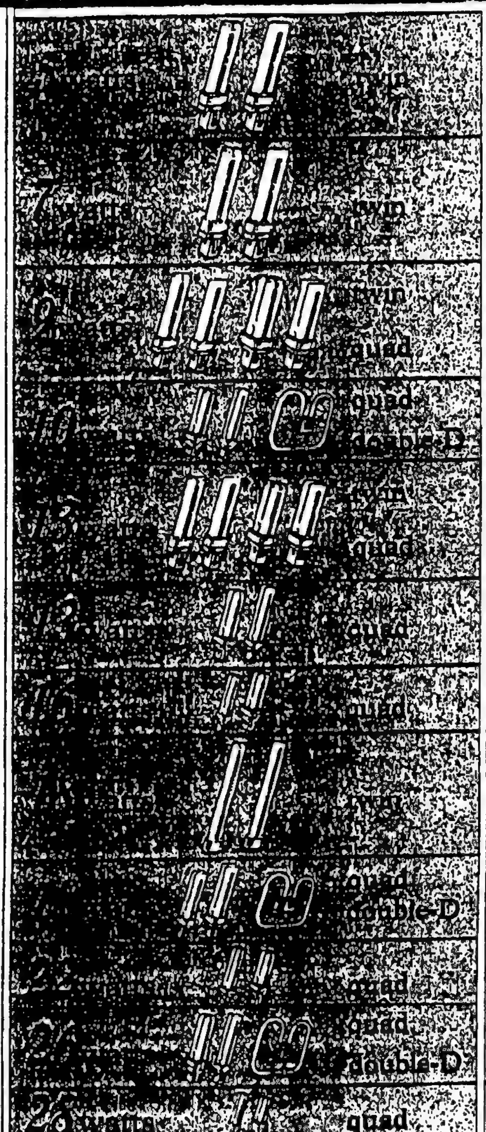
415 282 3296 12-14-93 02:22PM P001 #02

Ballasts for Twin and Quad Tube Lamps

Quick Reference

Electrical Characteristics — 60 Hertz

ONE LAMP / NORMAL POWER FACTOR



LAMP TYPE	LINE VOLTAGE	CATALOG NUMBER	OPERATING CURRENT (AMPERES)	STARTING CURRENT (AMPERES)
5W/4T4/T/G23/PH	120	4101F1P	0.18	0.175
	120	4101F2P	0.18	0.175
	120	4101P	0.18	0.175
	277	4205F1P	0.18	0.185
	277	4205F2P	0.18	0.185
	277	4205P	0.18	0.185
7W/5T4/T/G23/PH	120	4103F1P	0.18	0.200
	120	4103F2P	0.18	0.200
	120	4103P	0.18	0.200
	277	4205F1P	0.18	0.185
	277	4205F2P	0.18	0.185
	277	4205P	0.18	0.185
9W/6T4/T/G23/PH or 9W/4T4/Q/G23-2/PH	120	4105F1P	0.18	0.200
	120	4105F2P	0.18	0.200
	120	4105P	0.18	0.200
	277	4205F1P	0.18	0.185
	277	4205F2P	0.18	0.185
	277	4205P	0.18	0.185
10W/5T4/Q/G24d-1/PH or 10W/3.5T4/D/GR10Q/PH	120	4115P	0.40	0.450
	277	4217F1P	0.18	0.200
	277	4217F2P	0.18	0.200
	277	4217P	0.18	0.200
13W/7T4/T/GX23/PH or 13W/5T4/Q/GX23-2/PH	120	4111F1P	0.32	0.400
	120	4111F2P	0.32	0.400
	120	4111P	0.32	0.400
	277	4211F1P	0.32	0.345
	277	4211F2P	0.32	0.345
	277	4211P	0.32	0.345
13W/6T4/Q/G24d-1/PH	120	4115P	0.40	0.450
	277	4217F1P	0.18	0.200
	277	4217F2P	0.18	0.200
	277	4217P	0.18	0.200
15W/5T5/Q/GX32d-1/PH	120	4131F1P	0.40	0.550
	120	4131F2P	0.40	0.550
	120	4131P	0.40	0.550
18-20W/6T5/T/2G11/PH-RS	120	4131F1P	0.40	0.550
	120	4131F2P	0.40	0.550
	120	4131P	0.40	0.550
	277	4231F1P	0.32	0.300
	277	4231F2P	0.32	0.300
	277	4231P	0.32	0.300
16W/5.5T4/D/GR8/PH or 18W/7T4/Q/G24d-2/PH or 21W/5.5T4/D/GR10Q/PH	120	4116P	0.50	0.600
	277	4219F1P	0.24	0.280
	277	4219F2P	0.24	0.280
	277	4219P	0.24	0.280
20W/6T5/Q/GX32d-2/PH	120	4135F1P	0.45	0.620
	120	4135F2P	0.45	0.620
	120	4135P	0.45	0.620
26W/8T4/Q/G24d-3/PH or 26W/8T6/D/GR8/PH	120	4123P	0.62	0.580
	277	4223F1P	0.31	0.370
	277	4223F2P	0.31	0.370
	277	4223P	0.31	0.370
27W/7T5/Q/GX32d-3/PH	120	4139F1P	0.60	0.640
	120	4139F2P	0.60	0.640
	120	4139P	0.60	0.640

All encased ballasts on this page are available in a variety of lead and mounting options to match virtually any fixture requirement. See Page 10 for description, ordering suffixes and examples.

The standard color for encased ballasts listed on this page is white.

All ballasts are UL-approved, CSA-listed and designated Class P.

F1 indicates an open core & coil unit with no mounting feet.

F2 indicates an open core & coil unit with mounting feet.

Physical Characteristics

	[illegible]	[illegible]	Ballast Factor	Min. Start Temp.	Dimensions*	Wiring Diagram**	Units per Carton	Approx. Carton Weight (lbs.)	Catalog Number
		3	0.95	0°F	A1	1	48	14.0	4101F1P
		3	0.95	0°F	B1	1	48	14.0	4101F2P
		3	0.95	0°F	C1	1	30	14.0	4101P
		5	1.00	0°F	A2	1	36	21.0	4206F1P
		6	1.00	0°F	B2	1	36	21.0	4206F2P
		6	1.00	0°F	C2	1	30	21.0	4206P
		3	0.95	0°F	A1	1	48	14.0	4108F1P
		3	0.95	0°F	B1	1	48	14.0	4108F2P
		3	0.95	0°F	C1	1	30	14.0	4108P
		6	0.95	0°F	A2	1	36	21.0	4205F1P
		6	0.95	0°F	B2	1	36	21.0	4205F2P
		6	0.95	0°F	C2	1	30	21.0	4205P
		3	0.90	25°F	A1	1	47	14.0	4109F1P
		3	0.90	25°F	B1	1	47	14.0	4109F2P
		3	0.90	25°F	C1	1	30	28.0	4109P
		5	0.95	0°F	A2	1	36	21.0	4209F1P
		4	0.95	0°F	B2	1	36	21.0	4209F2P
		6	0.95	0°F	C2	1	30	21.0	4209P
	0.05	6	1.00	5°F	C5	2	20	34.0	4115P
		6	1.00	5°F	A2	1	36	21.0	4217F1P
		6	1.00	5°F	B2	1	36	21.0	4217F2P
		6	1.00	5°F	C2	1	30	26.0	4217P
		4	1.00	32°F	A2	1	36	21.0	4111F1P
		4	1.00	32°F	B2	1	36	21.0	4111F2P
		4	1.00	32°F	C2	1	30	26.0	4111P
		6	1.00	32°F	A3	1	36	37.5	4211F1P
		6	1.00	32°F	B3	1	36	37.5	4211F2P
		6	1.00	32°F	C3	1	24	37.0	4211P
	0.08	6	1.00	5°F	C5	2	20	34.0	4116P
		6	0.95	5°F	A2	1	36	21.0	4217F1P
		6	0.95	5°F	B2	1	36	21.0	4217F2P
		6	0.95	5°F	C2	1	30	26.0	4217P
		4	0.95	15°F	A2	1	36	21.0	4131F1P
		4	0.95	15°F	B2	1	36	21.0	4131F2P
		4	0.95	15°F	C2	1	30	21.0	4131P
		4	0.95	50°F	A2	1	36	21.0	4191F1P
		4	0.95	50°F	B2	1	36	21.0	4191F2P
		4	0.93	50°F	C2	1	30	21.0	4191P
		6	0.90	50°F	A3	1	36	37.5	4231F1P
		6	0.90	50°F	B3	1	36	37.5	4231F2P
		6	0.90	50°F	C3	1	24	37.0	4231P
	0.08	7	1.00	15°F	C5	2	20	34.0	4119P
		6	1.00	15°F	A3	1	36	37.5	4219F1P
		6	1.00	15°F	B3	1	36	37.5	4219F2P
		6	1.00	15°F	C3	1	24	37.0	4219P
		4	0.90	15°F	A2	1	36	21.0	4135F1P
		4	0.90	15°F	B2	1	36	21.0	4135F2P
		4	0.90	15°F	C2	1	30	26.0	4135P
	0.09	10	0.90	15°F	C5	3	20	40.0	4123P
		8	0.95	15°F	A3	1	36	37.5	4223F1P
		8	0.95	15°F	B3	1	36	37.5	4223F2P
		8	0.95	15°F	C3	1	24	37.0	4223P
		6	0.95	15°F	A3	1	36	37.5	4139F1P
		6	0.95	15°F	B3	1	36	37.5	4139F2P
		6	0.95	15°F	C2	1	24	37.0	4139P

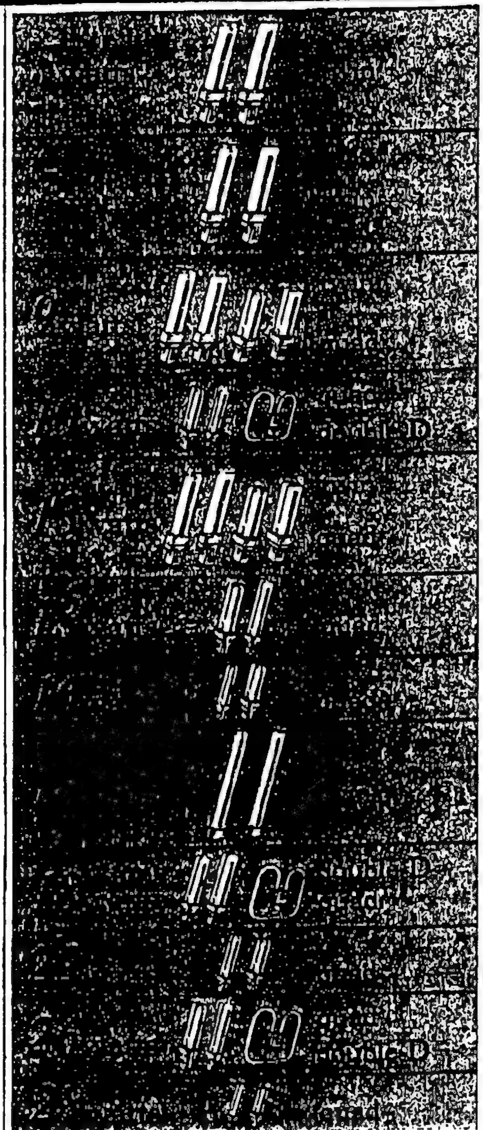
*See Pages 9-10 for physical dimensions of ballast types.

**See Page 9 for schematic wiring diagrams.

Ballasts for Twin and Quad Tube Lamps

Quick Reference | **Electrical Characteristics — 60 Hertz**

ONE LAMP / HIGH POWER FACTOR



Lamp Configuration and Nominal Watts	Lamp Type	Line Voltage	Catalog Number	Operating Current (Amperes)	Starting Current (Amperes)	[illegible]
	5W/4T4/T/G23/PH	120 277	4100P 4204P	0.07 0.05	0.08 0.06	
	7W/5T4/T/G23/PH	120 277	4104P 4204P	0.09 0.05	0.10 0.06	
	9W/6T4/T/G23/PH or 9W/4T4/Q/G23-2/PH	120 277	4104P 4204P	0.09 0.05	0.10 0.06	
	10W/5T4/Q/G24d-1/PH or 10W/3.5T4/D/GR10Q/PH	120 277	4116P 4216P	0.18 0.07	0.14 0.09	
	13W/7T4/T/GX23/PH or 13W/5T4/Q/GX23-2/PH	120 277	4110P 4210P	0.15 0.08	0.12 0.10	
	13W/6T4/Q/G24d-1/PH	120 277	4116P 4216P	0.18 0.07	0.14 0.09	
	15W/5T5/Q/GX32d-1/PH	120	4190P	0.18	0.31	
	18-28W/9T5/T/2G11/PH-RS	120 277	4130P 4230P	0.19 0.09	0.31 0.08	
	18W/5.5T4/D/GR8/PH or 18W/7T4/Q/G24d-2/PH 21W/5.5T4/D/GR10Q/PH	120 277	4120P 4220P	0.23 0.09	0.21 0.10	
	20W/6T5/Q/GX32d-2/PH	120	4124P	0.21	0.40	
	26W/6T4/Q/T24d-3/RH or 28W/6T8/D/GR8/PH	120 277	4124P 4224P	0.32 0.12	0.46 0.21	
	27W/7T8/Q/GX32d-3/PH	120	4138P	0.38	0.43	

All encased ballasts on this page are available in a variety of lead and mounting options to match virtually any fixture requirement. See Page 10 for description, ordering suffixes and examples.

The standard color for encased ballasts listed on this page is white.

All ballasts are UL-approved, CSA-listed and designated Class P.

F1 indicates an open core & coil unit with no mounting feet.

F2 indicates an open core & coil unit with mounting feet.

Physical Characteristics

	[illegible]	[illegible]	Ballast Factor	Min. Start Temp.	Dimensions*	Wiring Diagram**	Units Per Carton	Approx. Carton Weight (lbs.)	Catalog Number
	0.14 0.14	3 6	0.95 1.00	0°F 0°F	C2 C3	2 2	30 24	15.5 22.0	[illegible]
	0.12 0.14	3 6	0.95 0.95	0°F 0°F	C2 C3	2 2	30 24	15.5 22.0	[illegible]
	0.12 0.14	3 6	0.90 0.95	25°F 0°F	C2 C3	2 2	30 24	15.5 22.0	4104P 4204P
	0.36 0.14	6 5	1.00 1.00	5°F 5°F	C4 C3	2 2	20 24	41.0 22.0	[illegible]
	0.24 0.28	4 6	1.00 1.00	32°F 32°F	C3 C3	2 2	24 24	22.0 35.5	[illegible]
	0.30 0.14	6 6	1.00 0.95	5°F 5°F	C4 C3	2 2	20 24	41.0 22.0	[illegible]
	0.23	4	0.95	15°F	C3	2	24	22.0	[illegible]
	0.23 0.29	4 6	0.95 0.90	50°F 50°F	C3 C3	2 2	24 24	22.0 37.5	[illegible]
	0.29 0.21	7 6	1.00 1.00	15°F 15°F	C4 C3	2 2	20 24	41.0 37.5	[illegible]
	0.32	4	0.90	15°F	C3	2	24	22.0	[illegible]
	0.46 0.22	10 6	0.90 0.95	15°F 15°F	C4 C3	3 2	20 24	43.0 37.5	[illegible]
	0.51	6	0.95	15°F	C3	2	24	37.5	[illegible]

*See Pages 9-10 for physical dimensions of ballast types.

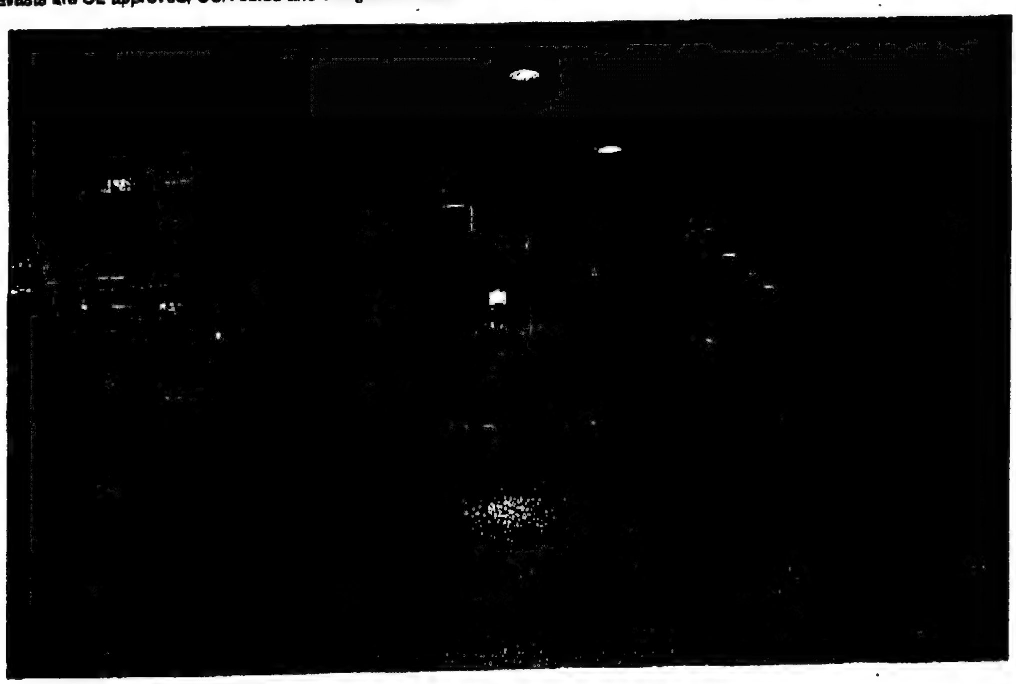
**See Page 9 for schematic wiring diagrams.

[illegible] Lamps

Electrical Characteristics — 60 Hertz

LAMP TYPE	[illegible]	[illegible]	LINE VOLTAGE	CATALOG NUMBER	LINE CURRENT (AMPERES)	OPEN CIRCUIT VOLTAGE	INPUT WATTS (ANSI)	BALLAST TYPE	MIN. START. TEMP.	SOUND RATING	[illegible]
ONE LAMP / HIGH POWER FACTOR											
(1) 24-27W/13T5/T/2G11/PH-RS	335	27	120 277	4146P 4246P	0.28 0.13	225 225	33 34	LEAD LEAD	+50°F +50°F	A A	
(1) 36-39W/16T5/T/2G11/PH-RS	430	39	120 277	4148P 4248P	0.44 0.19	235 230	52 52	LEAD LEAD	+50°F +50°F	A A	
(1) 40W/22T5/T/2G11/RS	270	40	120 277 347	[illegible] [illegible] [illegible]	0.39 0.17 0.15	300 300 300	45 46 46	LEAD LEAD LEAD	+50°F +50°F +50°F	A A A	
ONE LAMP / REDUCED LIGHT OUTPUT / HIGH POWER FACTOR											
(1) 40W/22T5/2G11/RS	270	40	120 277	4155P 4255P	0.330 0.145	300 300	37 37	LEAD LEAD	+50°F +50°F	A A	
TWO LAMP / HIGH POWER FACTOR											
(2) 24-27W/13T5/T/2G11/PH-RS	335	27	120 277	4149P 4249P	0.55 0.28	250 250	67 68	SERIES-LEAD SERIES-LEAD	+50°F +50°F	A A	
(2) 36-39W/16T5/T/2G11/PH-RS	430	39	120 277	4150P 4250P	0.78 0.33	335 330	[illegible] [illegible]	SERIES-LEAD SERIES-LEAD	+50°F +50°F	A A	
(2) 40W/22T5/T/2G11/RS	270	40	120 277 347	4152P 4252P 4352P	0.68 0.30 0.25	425 425 425	85 85 85	SERIES-LEAD SERIES-LEAD SERIES-LEAD	+50°F +50°F +50°F	A A A	
TWO LAMP / REDUCED LIGHT OUTPUT / HIGH POWER FACTOR											
(2) 40W/22T5/T/2G11/RS	270	40	120 277	4154P 4254P	0.62 0.28	425 425	70 70	SERIES-LEAD SERIES-LEAD	+50°F +50°F	A A	

All ballasts listed on this page, with the exception of 4154P, 4254P, 4155P and 4255P, are rated at a ballast factor of 0.95.
The 4154P, 4254P, 4155P and 4255P units are rated at a ballast factor of 0.80.
Unless otherwise noted, electrical data is based on ANSI C82.2 method of measurement.
Fixture light output and input watts may vary dependent upon voltage, ambient temperature and lamp temperature.
All ballasts are UL-approved, CSA-listed and designated Class P.



Physical Characteristics

[illegible]	Overall Dimensions (Inches)			Mounting Dimensions (Inches)		Lead Lengths in Inches (Tolerance: +2, -1 Inches)					Wiring Diagram	Units per Carton	Unit Net Weight (lbs.)	Approx. Carton Weight (lbs.)	Catalog Number
	Length	Width	Height	Length	Width	Black	White	Red	Blue	Yellow					
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	11	11	16-16	16-16		4	10	3.7	37	[illegible]
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	11	11	16-16	16-16		4	10	3.7	37	[illegible]
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30		4	10	3.7	37	[illegible]
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30		4	10	3.7	37	[illegible]
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30		4	10	3.8	38	4161P
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30		4	10	3.8	38	4261P
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30		4	10	3.8	38	4361P
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30		4	10	3.8	38	4158P
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30		4	10	3.8	38	4258P
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	11	11	16-16	16-16	16-16	5	10	3.8	38	4146P
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	11	11	16-16	16-16	16-16	5	10	3.8	38	[illegible]
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30	30-30	5	10	3.8	38	[illegible]
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30	30-30	5	10	3.8	38	[illegible]
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30	30-30	5	10	3.8	38	4162P
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30	30-30	5	10	3.8	38	4262P
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30	30-30	5	10	3.8	30	[illegible]
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30	30-30	5	10	3.8	38	[illegible]
	9 1/8	[illegible]	1 1/2	8 17/64	1 11/16	20	20	30-30	30-30	30-30	5	10	3.8	38	[illegible]

8

Appendix I

Energy Monitoring and Control System Calculations

APPENDIX I

Table of Contents

EMCS Energy Savings

Cooling Systems

Building	Option	Savings (KWH/YR)
451	Chiller Chilled Water Reset	3,285
451	Chiller Demand Limit (See Note 2)	10.7 kW Less Demand
506	Chiller No.1 Chilled Water Reset	105,485
506	Chiller No.2 Chilled Water Reset	47,815
2105	Chiller No.1 Demand Limit	0, Critical Load
2105	Chiller No.1 Chilled Water Reset	20,440
2105	Chiller No.2 Chilled Water Reset	364
2105	Chiller No.5 Chilled Water Reset	20,440
2105	Chiller No.5 Demand Limit	0, Critical Load
3490	Chiller No.1 Chilled Water Reset	4,015
3490	Chiller No.2 Chilled Water Reset	730
3490	Chiller No.3 Chilled Water Reset	15
3490	Chiller Nos. 1, 2 & 3 Demand Limit (See Note 2)	26.1 kW Less Demand
3490	Optimal Chiller Selection (Manifold Chillers)	92,825
Total	**Electric Load Savings (kW)**	**36.8**
Total	**Electric Energy Savings (kWH)**	**295,414**

Notes:

1. There is no significant energy savings associated with condenser water temperature reset, however, if an EMCS system is installed, this would be a recommended software option.

2. Demand Limiting avoids occurance of over-allocation elecrical demand charge, about $1,164/Yr cost saved. Based on $1.98/kW-Mo demand charge for 6 months, plus penalty of 10 times rate for one month.

3. Refer to Appendix F for detailed energy savings calculations for the above locally-controlled cooling system retrofits.

Heating Systems

Control measures identified for heating systems include:

- Remote Boiler Monitoring for boilers in Buildings: 451, 506, 2105 and 3510
- Hot Water Temperature Reset Control for Buildings: 451, 506, 2105 and 3510

The first measure will reduce operator labor hours for routine boiler inspections & daily change-over of operating boilers in bldg 506; included in cost savings for modular hot water boiler systems in the building - see calculations in Appendix C for Project No. B4A.

Remote Boiler Monitoring

Remote monitoring eliminates the need to perform personal inspection as often as they are conducted without monitoring systems. Alarms, should they occur, will be transmitted through the EMCS. It is assumed that savings of 1 labor hour per boiler per week is saved from this measure.

Avoided Cost of Steam Boiler Selection

Alternating two boilers between standby and active takes only a few moments for the operator, assume 2 minutes per day, 250 days per year are required for this activity. Modular boiler system selection (Project No. B4A) is automatic, no operator involvement is required.

Labor Cost Savings:

Remote Boiler Monitoring: Boilers x 1 Hr/Wk x 52 Wk/Yr x $22/Hr x 1.5 (OH + Benefits) =	$6,864.00 / Year
Avoided Cost of Steam Boiler Selection (Savings from Project B4A): 2 min / 60 Min/Hr x 250 Day/Yr x $22/Hr x 1.5 (OH+Benefits) =	$275.00 / Year
Total Labor Cost Savings:	**$7,139.00 / Year**

Hot Water Temperature Reset Control

Reducing the hot water supply temperature by adjusting set points reduces conduction losses from piping and improves boiler performance. Control retrofits consist of differential temperature controllers that adjust hot water boiler set points proportionally in the range of 200 Deg F to 180 Deg F when outside air temperatures are between 40 Deg F and 65 Deg F. A temperature of 200 Deg F, the existing heating hot water supply temperature, is used when outside air temperatures are below 40 Deg F. No heating is assumed required when the outside air temperature exceeds 65 Deg F.

Boiler Performance Improvement:

k = f(BTU / Temp Diff per inch per sqft)

Lowering HHW temp will result in the same boiler k: k1 = k2 since the thickness (inches) and area (sqft) remain constant. Thus:

BTUH2 / Temp Diff 2 = BTUH1 / Temp Diff 1,
BTUH2 = (Temp Diff 2 / Temp Diff 1) x (BTUH1 / Temp Diff 1)

represents increased heat transfer efficiency, where:

Temp Diff 1 = 750 Deg F - [(200 + 180) / 2] = 560 Deg F
Temp Diff 2 = 750 Deg F - [(180 + 160) / 2] = 580 Deg F
Temp Diff 1 = Combined temperature less HHW Avg Temp (200 Deg F supply, 180 Deg F return assumed 20 Deg F Temp Diff HHW)
Temp Diff 2 = Same as Temp Diff 1 except reduced to 180 Deg F supply and 160 Deg F return

Note: Return temperature minimum should be 160 Deg F to prevent condensing in the boiler. Average temperature in boiler 750 Deg F

BTUH2 = 580 / 560 x BTUH1 = 1.0357, or a 3.57% efficiency improvement when outside air temperature is 65 Deg F.

Average efficiency improvement is:
3.57 x (Deg-Hrs between 40Deg F & 65 Deg F) / (Deg-Hrs below 65 Deg F)
For Yuma, this is: 3.57 x (28,518 / 30,388) = 3.35%

Boilers included: Building 451, 2105 and 3510
Fuel Delivery Records for 451 and 2105 (No records available for 3510):

Building 451:

LPG (Gal) 13,756
BTU/Yr = 1,306,820,000
Summer minimum, 700 Gallons/Mo, subtracting this amount per month, allowing for cooking:
Htg BTU/Yr = 508,820,000

Assuming an efficiency of 80%, a 3.35% improvement yields the following savings:
LPG Saved (BTU/Yr) = 20,452,298

$/Yr = $150.73

Building 506:

Energy conservation project recommendations for the steam boilers serving building 506 include Project No. B4A, involving the installation of a modular HW heating boiler system to improve efficiency. A portion of the energy savings for this project (see Appendix C calculations) include effects of outside temperature reset controls. The amount attributable to this control scheme is determined below:

From above, savings total about 3.35% for outside temperature reset controls.

No. 2 Fuel Oil:

Energy use befor Project B4A (MBTU/Year) =	1,615
Existing Average Plant Efficiency =	54.5%
Existing Load (MBTU/Year) =	880
Improved Efficiency After Project No. B4A =	76.6%
Energy Savings (MBTU/Year) =	466
Total Efficency Improvement =	22.1%
Portion Attributable to Outside Temp. Reset =	15.2% of 22.1%
HW Reset Control Saving (MBTU/Year) =	70.6
Energy Cost ($/MBTU) =	$13.25
Annual Energy Cost Savings ($/Year) =	$936
LCC UPW for N = 15 Years =	12.18
Life Cycle Energy Cost Saved ($) =	$11,399

LPG:

Energy use befor Project B4A (MBTU/Year) =	1,496
Existing Average Plant Efficiency =	46.5%
Existing Load (MBTU/Year) =	696
Improved Efficiency After Project No. B4A =	75.8%
Energy Savings (MBTU/Year) =	578
Total Efficency Improvement =	29.3%
Portion Attributable to Outside Temp. Reset =	11.4% of 29.3%
HW Reset Control Saving (MBTU/Year) =	66.1
Energy Cost ($/MBTU) =	$7.37
Annual Energy Cost Savings ($/Year) =	$487
LCC UPW for N = 15 Years =	13.25
Life Cycle Energy Cost Saved ($) =	$6,456

Building 2105:

#2 FO (Gal): 5,539

BTU/Yr = 768,259,300

#2 FO Saved (BTU/Yr) = 30,880,602

$/Yr = $409.17

SUMMARY HEATING FUEL SAVINGS

Building	LPG	No. 2 FO	Total
451 (MBTU/Year)	20.45	-	20.45
506 (MBTU/Year)	66.12	70.63	136.75
2105 (MBTU/Year)	-	30.88	30.88
Total (MBTU/Year)	86.57	101.51	188.08
Cost ($/MBTU)	$7.37	$13.25	
Annual Savings ($/Year)	$638	$1,345	$1,983
UPW, N = 15 Years	13.25	12.18	
LCC Savings ($)	$8,454	$16,382	$24,836

SUMMARY OPERATION & MAINTENANCE COSTS

Remote Boiler Monitoring & Boiler Selection Savings ($/Year)	$7,139
LCC UPW for N = 15 Years	10.22
LCC O&M Cost Savings	$72,961

EMCS HARDWARE REQUIREMENTS

Chilled Water EMCS System

Bulding	AI	Modules	AO	Modules	DI	Modules	DO	Modules	Total Modules	RTU,s
451	2	1	1	1	0	0	0	0	2	1
506	17	3	3	1	6	1	7	1	6	1
2105	33	5	6	2	12	1	14	1	9	2
3482	1	1	1	1	0	0	0	0	2	1
3490	20	3	3	1	6	1	6	1	6	1
3510	1	1	1	1	0	0	0	0	2	1
Total	74	14	15	7	24	3	27	3	27	7

Notes:

1. Each analog input module has capacity for 8 inputs
2. Each analog output module has capacity for 4 outputs
3. Each digital input module has capacity for 16 inputs
4. Each digital output module has capacity for 16 outputs
5. Each remote terminal unit has capacity for 6 modules

EMCS INPUT/OUTPUT REQUIREMENTS

Chilled Water EMCS System

Bulding	Inputs									Outputs		
	DPS	AUX	Wtr. Temp	KW	Amps	Flow	Position	Air Temp	RH %	Relay	Step	C.P.A.
451	0	0	1	0	0	0	1	0	0	0	0	1
506	4	2	8	6	1	0	2	0	0	6	1	3
2105	9	3	10	12	3	1	3	0	0	12	2	5
3482	0	0	1	0	0	0	0	0	0	0	0	1
3490	3	3	12	6	0	1	3	0	0	6	0	3
3510	0	0	1	0	0	0	0	0	0	0	0	1
System	0	0	0	0	0	0	0	1	1	0	0	0
Total	16	8	33	24	4	2	9	1	1	24	3	14

DPS	Differential Pressure Switch
AUX	Auxilliary Contact
Wtr. Temp	Thermometer (Water)
KW	KW Transducer
AMP	Current Meter
Flow	Flow Meter
Position	Valve Position Sensor
Air Temp	Thermometer (Air)
RH %	Humidity Meter
Relay	On/Off Relay
Step	Step Relay
C.P.A.	Control Point Adjustment

EMCS HARDWARE REQUIREMENTS

Boiler EMCS System

Bulding	AI	Modules	AO	Modules	DI	Modules	DO	Modules	Total Modules	RTU,s
451	5	1	0	0	2	1	2	1	3	1
506	10	2	0	0	4	1	4	1	4	1
2105	7	1	0	0	3	1	4	1	3	1
3482	-	-	-	-	-	-	-	-	-	-
3490	4	1	0	0	2	1	2	1	3	1
3510	4	1	0	0	1	1	2	1	3	1
Total	30	6	0	0	12	5	14	5	16	5

Notes:

1. Each analog input module has capacity for 8 inputs
2. Each analog output module has capacity for 4 outputs
3. Each digital input module has capacity for 16 inputs
4. Each digital output module has capacity for 16 outputs

EMCS INPUT/OUTPUT REQUIREMENTS

Boiler EMCS System

Bulding	Inputs								Outputs	
	AUX	Flame	Wat. Temp.	Wat. Flow	F. Flow	Stm. Press.	Stm. Temp.	Stm. Flow	Relay	H/O
451	1	1	2	2	1	0	0	0	1	1
506	2	2	1	1	2	2	2	2	2	2
2105	2	1	4	2	1	0	0	0	2	2
3482	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3490	1	1	2	1	1	0	0	0	1	1
0	0	1	2	1	1	0	0	0	1	1
System	0	0	4	2	0	1	1	0	0	0
Total	6	6	15	9	6	3	3	2	7	7

AUX	Auxillliary Contact
Flame	Flame Status
Wat. Temp.	Thermometer (Water)
Wat. Flow	Flow Meter (Water)
F. Flow	Flow Meter (Fuel)
Stm. Press	Pressure Gauge (Steam)
Stm. Temp.	Thermometer (Steam)
Stm. Flow	Flow Meter (Steam)
Relay	On/Off Reley
H/O	Hand/Off Relay

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)

Sheet 1 of 1

Location: Yuma Proving Ground, Arizona — Region No. — Project No.
Project Title: Chiller Study — Fiscal Year FY96
Discrete Portion Name: Limited EMCS (Buildings 451, 506, 2105, 3490 and 3510)
Analysis Date: January 1994 — Economic Life: 15 YEARS — Preparer: KELLER & GANNON

1. Investment Costs

A. Construction Costs	$426,268		
B. SIOH	$25,576		
C. Design Cost	$25,576		
D. Total Cost (1A+1B+1C)	$477,420		
E. Salvage Value of Existing Equipment			
F. Public Utility Company Rebate		$0	
G. Total Investment (1D-1E-1F)			$477,420

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-X Used for Discount Factors: October 1993

Energy Source	Cost (1) $/KWH @ Elec $/MBTU @ Fuel	Saving (2) KWH/YR @ Elec MBTU/YR @ Fuel	Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$0.083	295,414	$24,519	11.30	$277,069
B. Dist	$13.25	101.5	$1,345	12.18	$16,382
C. LPG	$7.37	86.6	$638	13.25	$8,454
D. Other					
E. Demand Savings	$1.98/kW-Mo	36.8 kW	$1,164	11.30	$13,157
F. Total	Based on $1.98/kW-Mo @ 6 Months + 10 times rate for 1 Mo.		$27,667		$315,062

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-) (Maintenance, see below)	($2,365)		
(1) Discount Factor (Table A)		10.22	
(2) Discounted Savings/Cost (3A x 3A1)			($24,170)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.				
b.				
c.				
d. Total				

C Total Non Energy Discounted Savings (3A2+3Bd4) ($24,170)

4. Simple Payback 1G/(2F3+3A+(3Bd1/Economic Life)):	18.87	Years
5. Total Net Discounted Savings (2F5+3C):	$290,891	
6. Savings to Investment Ratio (SIR) 5/1G:	0.61	
7. Adjusted Internal Rate of Return (AIRR):	1.10%	

Added Maintenance (Chillers) = 4 Man Hr. x 6 Bldgs x 12 x $22/Hr x 1.5(benefits & overhead) = $9,504/Yr Assume 4 man hour per building per month;
Saved Maintenance (Boilers) = $7,139/Yr.

IO SUMMARY TABLE

BUILDING NO.

451

SYSTEM

CHILLED WATER

POINT DISCRIPTION	HARDWARE – OUTPUT FROM EMCS – DIGITAL: CONTROL RELAY	STEP CONTROL	OUTPUT FROM EMCS – ANALOG: CONTROL POINT ADJUSTMENT	TOWER FAN C.P.A.	INPUT TO EMCS – DIGITAL: DIFFERENTIAL PRESSURE SWITCH	AUXILLARY CONTACT	INPUT TO EMCS – ANALOG: CONDENSER WATER RETURN (TEMP)	CONDENSER WATER SUPPLY (TEMP)	CHILLED WATER SUPPLY (TEMP)	CHILLED WATER RETURN (TEMP)	INSTANTANEOUS KW	CHILLER CURRENT	FLOW	TEMPERATURE	POSITION	RELATIVE HUMIDITY	SOFTWARE – ALARMS – DIGITAL	ALARMS – ANALOG	SOFTWARE – APPLICATION PROGRAMS: CHILLER SELECTION	CHILLED WATER RESET	CONDENSER WATER RESET	CHILLER DEMAND LIMIT
CHILLER #1			●						●											●		
CHW VALVE #1															●							
OUTSIDE AIR*														●		●						

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 3
NUMBER OF SOFTWARE PACKAGES = 1

IO SUMMARY TABLE

BUILDING NO.

506

SYSTEM

CHILLED WATER

POINT DISCRIPTION	HARDWARE																SOFTWARE			
	OUTPUT FROM EMCS				INPUT TO EMCS												APPLICATION PROGRAMS			
	DIGITAL		ANALOG		DIGITAL		ANALOG													
	CONTROL RELAY	STEP CONTROL	CONTROL POINT ADJUSTMENT	TOWER FAN C.P.A.	DIFFERENTIAL PRESSURE SWITCH	AUXILLARY CONTACT	CONDENSER WATER RETURN (TEMP)	CONDENSER WATER SUPPLY (TEMP)	CHILLED WATER SUPPLY (TEMP)	CHILLED WATER RETURN (TEMP)	INSTANTANEOUS KW	CHILLER CURRENT	FLOW	TEMPERATURE	POSITION	RELATIVE HUMIDITY	CHILLER SELECTION	CHILLED WATER RESET	CONDENSER WATER RESET	CHILLER DEMAND LIMIT
																	●	●		●
CHILLER #1	●	●	●			●	●	●	●	●	●	●								
CHW VALVE #1													●							
CHW PUMP	●				●						●									
CW PUMP	●				●						●									
TOWER CT-1	●			●	●						●								●	
CHILLER #2	●		●			●	●	●	●	●	●						●	●		
CHW VALVE #2															●					
CHW PUMP	●				●						●									
OUTSIDE AIR*														●		●				

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 33
NUMBER OF SOFTWARE PACKAGES = 3

IO SUMMARY TABLE

BUILDING NO.

2105

SYSTEM

CHILLED WATER

POINT DISCRIPTION	HARDWARE																SOFTWARE			
	OUTPUT FROM EMCS				INPUT TO EMCS												ALARMS (DIGITAL / ANALOG)	APPLICATION PROGRAMS		
	DIGITAL		ANALOG		DIGITAL		ANALOG													
	CONTROL RELAY	STEP CONTROL	CONTROL POINT ADJUSTMENT	TOWER FAN C.P.A.	DIFFERENTIAL PRESSURE SWITCH	AUXILLARY CONTACT	CONDENSER WATER RETURN (TEMP)	CONDENSER WATER SUPPLY (TEMP)	CHILLED WATER SUPPLY (TEMP)	CHILLED WATER RETURN (TEMP)	INSTANTANEOUS KW	CHILLER CURRENT	FLOW	TEMPERATURE	POSITION	RELATIVE HUMIDITY	CHILLER SELECTION	CHILLED WATER RESET	CONDENSER WATER RESET	CHILLER DEMAND LIMIT
CHILLER #1	●	●	●			●	●	●	●	●	●	●					●	●		●
CHW VALVE #1															●					
CHWS PUMP #4	●				●						●									
CHWR PUMP #12	●				●						●									
CW PUMP #6	●				●						●									
TOWER CT-1	●			●	●						●								●	
CHILLER #2	●		●			●	●	●	●	●	●	●					●	●		
CHW VALVE #2															●					
CHW PUMP #11	●				●						●									
CW PUMP #5	●				●						●									
CHILLER #5	●	●	●			●	●	●	●	●	●	●					●	●		●
CHW VALVE #5															●					
CHW PUMP #7	●				●						●									
CW PUMP #8	●				●						●									
TOWER CT-3	●			●	●						●								●	
SYSTEM*									●	●			●							
OUTSIDE AIR*														●		●				

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 64
NUMBER OF SOFTWARE PACKAGES = 4

IO SUMMARY TABLE

BUILDING NO.

3482

SYSTEM

CHILLED WATER

POINT DISCRIPTION	HARDWARE – OUTPUT FROM EMCS – DIGITAL: CONTROL RELAY	STEP CONTROL	HARDWARE – OUTPUT FROM EMCS – ANALOG: CONTROL POINT ADJUSTMENT	TOWER FAN C.P.A.	HARDWARE – INPUT TO EMCS – DIGITAL: DIFFERENTIAL PRESSURE SWITCH	AUXILLARY CONTACT	HARDWARE – INPUT TO EMCS – ANALOG: CONDENSER WATER RETURN (TEMP)	CONDENSER WATER SUPPLY (TEMP)	CHILLED WATER SUPPLY (TEMP)	CHILLED WATER RETURN (TEMP)	INSTANTANEOUS KW	CHILLER CURRENT	FLOW	TEMPERATURE	POSITION	RELATIVE HUMIDITY	SOFTWARE – ALARMS – DIGITAL	SOFTWARE – ALARMS – ANALOG	SOFTWARE – APPLICATION PROGRAMS: CHILLER SELECTION	CHILLED WATER RESET	CONDENSER WATER RESET	CHILLER DEMAND LIMIT
DX UNIT #1								●													●	
TOWER CT-1				●																		
OUTSIDE AIR*														●		●						

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 2
NUMBER OF SOFTWARE PACKAGES = 1

IO SUMMARY TABLE

BUILDING NO. **3490**

SYSTEM **CHILLED WATER**

POINT DISCRIPTION	HARDWARE																SOFTWARE			
	OUTPUT FROM EMCS				INPUT TO EMCS												APPLICATION PROGRAMS			
	DIGITAL		ANALOG		DIGITAL		ANALOG													
	CONTROL RELAY	STEP CONTROL	CONTROL POINT ADJUSTMENT	TOWER FAN C.P.A.	DIFFERENTIAL PRESSURE SWITCH	AUXILLARY CONTACT	CONDENSER WATER RETURN (TEMP)	CONDENSER WATER SUPPLY (TEMP)	CHILLED WATER SUPPLY (TEMP)	CHILLED WATER RETURN (TEMP)	INSTANTANEOUS KW	CHILLER CURRENT	FLOW	TEMPERATURE	POSITION	RELATIVE HUMIDITY	CHILLER SELECTION	CHILLED WATER RESET	CONDENSER WATER RESET	CHILLER DEMAND LIMIT
CHILLER #1	●		●			●	●	●	●	●	●						●	●		
CHW VALVE #1															●					
CHWS PUMP #1	●				●						●									
CHILLER #2	●		●			●	●	●	●	●	●						●	●		
CHW VALVE #2															●					
CHW PUMP #2	●				●						●									
CHILLER #3	●		●			●	●	●	●	●	●						●	●		
CHW VALVE #3															●					
CHW PUMP #3	●				●						●									
SYSTEM												●								
OUTSIDE AIR*														●		●				

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 37
NUMBER OF SOFTWARE PACKAGES = 2

IO SUMMARY TABLE

BUILDING NO.

3510

SYSTEM

CHILLED WATER

	HARDWARE																SOFTWARE					
	OUTPUT FROM EMCS				INPUT TO EMCS												ALARMS		APPLICATION PROGRAMS			
	DIGITAL		ANALOG		DIGITAL		ANALOG										DIGITAL	ANALOG				
POINT DISCRIPTION	CONTROL RELAY	STEP CONTROL	CONTROL POINT ADJUSTMENT	TOWER FAN C.P.A.	DIFFERENTIAL PRESSURE SWITCH	AUXILLARY CONTACT	CONDENSER WATER RETURN (TEMP)	CONDENSER WATER SUPPLY (TEMP)	CHILLED WATER SUPPLY (TEMP)	CHILLED WATER RETURN (TEMP)	INSTANTANEOUS KW	CHILLER CURRENT	FLOW	TEMPERATURE	POSITION	RELATIVE HUMIDITY			CHILLER SELECTION	CHILLED WATER RESET	CONDENSER WATER RESET	CHILLER DEMAND LIMIT
DX UNIT #1								●													●	
TOWER CT-1				●																		
OUTSIDE AIR*														●		●						

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 2
NUMBER OF SOFTWARE PACKAGES = 1

IO SUMMARY TABLE

BUILDING NO.

451

SYSTEM

HOT WATER BOILER

			POINT DISCRIPTION	BOILER #1	SYSTEM*	OUTSIDE AIR*
HARDWARE	OUTPUT FROM EMCS	DIGITAL	CONTROL RELAY	●		
			SOLENOID			
			HAND/OFF	●		
		ANALOG				
	INPUT TO EMCS	DIGITAL	AUXILIARY CONTACT	●		
			FLAME STATUS	●		
			BOILER WATER LEVEL			
		ANALOG	HOT WATER SUPPLY TEMPERATURE	●		
			HOT WATER RETURN TEMPERATURE	●		
			HOT WATER FLOW	●		
			COMMON HWS TEMPERATURE		●	
			COMMON HWR TEMPERATURE		●	
			TOTAL HOT WATER FLOW		●	
			OIL TEMPERAURE			
			PRESSURE			
			FUEL FLOW	●		
			STEAM SUPPLY PRESSURE			
			STEAM TEMPERATURE			
			STEAM FLOW			
			FUEL TEMPERATURE			
			FEED WATER FLOW			
			FEED WATER TEMPERATURE			
			COMMON STEAM SUPPLY PRESS.			
			COOMON STEAM SUPPLY TEMP.			
			COMMON COND. RET. TOT. FLOW			
			COMMON COND. RETURN TEMP.			
			FLUE GAS ANALYZER			
SOFTWARE	ALARMS	DIGITAL				
		ANALOG				
	APPLICATION PROGRAMS		STEAM BOILER SELECTION			
			HOT WATER BOILER SELECTION			
			REMOTE BOILER MONITORING		●	
			HOT WATER OA RESET		●	

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 13
NUMBER OF SOFTWARE PACKAGES = 2

IO SUMMARY TABLE

BUILDING NO.

506

SYSTEM

MODULAR HOT WATER BOILER

POINT DISCRIPTION	HARDWARE – OUTPUT FROM EMCS – DIGITAL: CONTROL RELAY	SOLENOID	HAND/OFF	HARDWARE – OUTPUT FROM EMCS – ANALOG	HARDWARE – INPUT TO EMCS – DIGITAL: AUXILIARY CONTACT	FLAME STATUS	BOILER WATER LEVEL
MODULAR BOILER	●		●	●	●	●	
SYSTEM*							
OUTSIDE AIR*							

POINT DISCRIPTION	HARDWARE – INPUT TO EMCS – ANALOG: HOT WATER SUPPLY TEMPERATURE	HOT WATER RETURN TEMPERATURE	HOT WATER FLOW	COMMON HWS TEMPERATURE	COMMON HWR TEMPERATURE	OIL TEMPERAURE	PRESSURE	FUEL FLOW	STEAM SUPPLY PRESSURE	STEAM TEMPERATURE	STEAM FLOW
MODULAR BOILER	●	●	●					●			
SYSTEM*											
OUTSIDE AIR*											

POINT DISCRIPTION	FUEL TEMPERATURE	FEED WATER FLOW	FEED WATER TEMPERATURE	COMMON STEAM SUPPLY PRESS.	COOMON STEAM SUPPLY TEMP.	COMMON COND. RET. TOT. FLOW	COMMON COND. RETURN TEMP.	FLUE GAS ANALYZER
MODULAR BOILER		●	●					
SYSTEM*				●	●	●	●	
OUTSIDE AIR*								

POINT DISCRIPTION	SOFTWARE – ALARMS – DIGITAL	SOFTWARE – ALARMS – ANALOG	SOFTWARE – APPLICATION PROGRAMS: STEAM BOILER SELECTION	HOT WATER BOILER SELECTION	REMOTE BOILER MONITORING	HOT WATER OA RESET
MODULAR BOILER						
SYSTEM*			●		●	●
OUTSIDE AIR*						

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 15
NUMBER OF SOFTWARE PACKAGES = 3

IO SUMMARY TABLE

BUILDING NO.

2105

SYSTEM

HOT WATER BOILER

	HARDWARE													
	OUTPUT FROM EMCS			INPUT TO EMCS										
	DIGITAL			DIGITAL			ANALOG							
POINT DISCRIPTION	CONTROL RELAY	SOLENOID	HAND/OFF	AUXILIARY CONTACT	FLAME STATUS	BOILER WATER LEVEL	HOT WATER SUPPLY TEMPERATURE	HOT WATER RETURN TEMPERATURE	HOT WATER FLOW	COMMON HWS TEMPERATURE	COMMON HWR TEMPERATURE	TOTAL HOT WATER FLOW	OIL TEMPERAURE	PRESSURE
BOILER #1	●		●	●	●		●	●	●				●	
SOLAR SYSTEM	●		●	●			●	●	●					
SYSTEM*										●	●	●		
OUTSIDE AIR*														

	HARDWARE												SOFTWARE			
	INPUT TO EMCS												APPLICATION PROGRAMS			
	ANALOG															
POINT DISCRIPTION	FUEL FLOW	STEAM SUPPLY PRESSURE	STEAM TEMPERATURE	STEAM FLOW	FUEL TEMPERATURE	FEED WATER FLOW	FEED WATER TEMPERATURE	COMMON STEAM SUPPLY PRESS.	COOMON STEAM SUPPLY TEMP.	COMMON COND. RET. TOT. FLOW	COMMON COND. RETURN TEMP.	FLUE GAS ANALYZER	STEAM BOILER SELECTION	HOT WATER BOILER SELECTION	REMOTE BOILER MONITORING	HOT WATER OA RESET
BOILER #1	●															
SOLAR SYSTEM																
SYSTEM*															●	●
OUTSIDE AIR*																

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 18
NUMBER OF SOFTWARE PACKAGES = 2

IO SUMMARY TABLE

BUILDING NO.

3490

SYSTEM

HOT WATER BOILER

	HARDWARE																																							SOFTWARE							
	OUTPUT FROM EMCS										INPUT TO EMCS																								ALARMS						APPLICATION PROGRAMS							
	DIGITAL						ANALOG				DIGITAL				ANALOG																				DIGITAL			ANALOG										
POINT DISCRIPTION	CONTROL RELAY	SOLENOID	HAND/OFF								AUXILIARY CONTACT	FLAME STATUS	BOILER WATER LEVEL		HOT WATER SUPPLY TEMPERATURE	HOT WATER RETURN TEMPERATURE	HOT WATER FLOW	COMMON HWS TEMPERATURE	COMMON HWR TEMPERATURE	TOTAL HOT WATER FLOW	OIL TEMPERAURE	PRESSURE	FUEL FLOW	STEAM SUPPLY PRESSURE	STEAM TEMPERATURE	STEAM FLOW	FUEL TEMPERATURE	FEED WATER FLOW	FEED WATER TEMPERATURE	COMMON STEAM SUPPLY PRESS.	COOMON STEAM SUPPLY TEMP.	COMMON COND. RET. TOT. FLOW	COMMON COND. RETURN TEMP.	FLUE GAS ANALYZER							STEAM BOILER SELECTION	HOT WATER BOILER SELECTION	REMOTE BOILER MONITORING	HOT WATER OA RESET				
BOILER #1	●		●								●	●			●	●	●						●																									
SYSTEM*																		●	●	●																							●	●				
OUTSIDE AIR*																																																

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 11
NUMBER OF SOFTWARE PACKAGES = 2

IO SUMMARY TABLE

BUILDING NO. **3510**

SYSTEM **HOT WATER BOILER**

HARDWARE

POINT DISCRIPTION	OUTPUT FROM EMCS – DIGITAL: CONTROL RELAY	OUTPUT FROM EMCS – DIGITAL: SOLENOID	OUTPUT FROM EMCS – DIGITAL: HAND/OFF	INPUT TO EMCS – DIGITAL: AUXILIARY CONTACT	INPUT TO EMCS – DIGITAL: FLAME STATUS	INPUT TO EMCS – DIGITAL: BOILER WATER LEVEL	INPUT TO EMCS – ANALOG: HOT WATER SUPPLY TEMPERATURE	HOT WATER RETURN TEMPERATURE	HOT WATER FLOW	COMMON HWS TEMPERATURE	COMMON HWR TEMPERATURE	TOTAL HOT WATER FLOW	OIL TEMPERAURE	PRESSURE	FUEL FLOW
BOILER #1	●		●	●	●		●	●	●						●
SYSTEM*										●	●	●	●		
OUTSIDE AIR*															

POINT DISCRIPTION	INPUT TO EMCS – ANALOG: STEAM SUPPLY PRESSURE	STEAM TEMPERATURE	STEAM FLOW	FUEL TEMPERATURE	FEED WATER FLOW	FEED WATER TEMPERATURE	COMMON STEAM SUPPLY PRESS.	COOMON STEAM SUPPLY TEMP.	COMMON COND. RET. TOT. FLOW	COMMON COND. RETURN TEMP.	FLUE GAS ANALYZER	SOFTWARE – APPLICATION PROGRAMS: STEAM BOILER SELECTION	HOT WATER BOILER SELECTION	REMOTE BOILER MONITORING	HOT WATER OA RESET
BOILER #1															
SYSTEM*														●	●
OUTSIDE AIR*															

SOFTWARE – ALARMS: DIGITAL | ANALOG

NOTES: * ONE FOR ENTIRE SYSTEM

TOTAL NUMBER OF POINTS = 14
NUMBER OF SOFTWARE PACKAGES = 2

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1 of 1
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: Code A (no design competed)
Location: Yuma Proving Ground, Arizona		
Engineer-Architect: Keller & Gannon		
Drawing No.	Estimator: R.Bush	Checked By: B.Horst

Energy Monitoring & Control System	Quantity		Labor		Material		Total
Line Item	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Total Cost
Data Transmission System							
1. Headend Transceiver	1	EA	$300	$300	$6,800	$6,800	$7,100
2. Headend Antenna	1	EA	$75	$75	$800	$800	$875
3. Radio Tower	1	EA	$1,300	$1,300	$1,575	$1,575	$2,875
4. Remote Antenna (9.5 dB)	4	EA	$30	$120	$290	$1,160	$1,280
5. Remote Antenna (2.5 dB)	2	EA	$30	$60	$85	$170	$230
6. Repeater and Duplexer	1	EA	$500	$500	$10,000	$10,000	$10,500
7. Repeater Antenna / Tower	1	EA	$1,375	$1,375	$2,375	$2,375	$3,750
Central Control Station							
1. Computer	1	EA		$0	$9,500	$9,500	$9,500
2. Alarm & Logging Printers	2	EA		$0	$600	$1,200	$1,200
3. Line Conditioner / UPS	1	EA		$0	$1,300	$1,300	$1,300
4. Database Generation	200	PTS	$25	$5,000		$0	$5,000
5. Command Software	1	LS		$13,000		$0	$13,000
6. Installation Labor	40	MH	$30	$1,200		$0	$1,200
Subtotal				$22,930		$34,880	$57,810
State Sales Tax	5.5%	%		-		$1,918	$1,918
Subtotal							$59,728
Contractor OH & Profit	30.0%	%					$17,919
Subtotal							$77,647
Bond	1.0%	%					$776
Subtotal							$78,423
Estimating Contingency	10.0%	%					$7,842
Total Probable Construction Cost							**$86,266**

CONSTRUCTION COST ESTIMATE				Date Prepared January 1994		Sheet 1	of 3
Project EEAP Limited Energy Study				Project No.	Basis for Estimate Code A (no design competed)		
Location Yuma Proving Ground, Arizona							
Engineer-Architect Keller & Gannon							
Drawing No. Chilled Water EMCS System		Estimator R.Bush			Checked By B.Horst		

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Building 451							
Thermometer (Water)	1	EA	$50	$50	$550	$550	$600
Valve Position Sensor	1	EA	$50	$50	$300	$300	$350
Control Point Adjustment	1	EA	$50	$50	$300	$300	$350
Analog Input Module	1	EA	$100	$100	$635	$635	$735
Analog Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	1	EA	$200	$200	$3,570	$3,570	$3,770
Sub Total Bldg. 451				$550		$5,855	$6,405
Building 506							
Differential Pressure Switch	4	EA	$50	$200	$730	$2,920	$3,120
Auxilliary Contact	2	EA	$50	$100	$350	$700	$800
Thermometer (Water)	8	EA	$50	$400	$550	$4,400	$4,800
KW Transducer	6	EA	$50	$300	$1,200	$7,200	$7,500
Current Meter	1	EA	$50	$50	$1,200	$1,200	$1,250
Valve Position Sensor	2	EA	$50	$100	$300	$600	$700
On/Off Relay	6	EA	$50	$300	$280	$1,680	$1,980
Step Relay	1	EA	$50	$500	$550	$550	$1,050
Control Point Adjustment	3	EA	$50	$150	$300	$900	$1,050
Analog Input Module	3	EA	$100	$300	$635	$1,905	$2,205
Analog Output Module	1	EA	$100	$100	$500	$500	$600
Digital Input Module	1	EA	$100	$100	$280	$280	$380
Digital Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	1	EA	$200	$200	$3,570	$3,570	$3,770
Sub Total Bldg. 451				$2,900		$26,905	$29,805
Building 2105							
Differential Pressure Switch	9	EA	$50	$450	$730	$6,570	$7,020
Auxilliary Contact	3	EA	$50	$150	$350	$1,050	$1,200
Thermometer (Water)	10	EA	$50	$500	$550	$5,500	$6,000
KW Transducer	12	EA	$50	$600	$1,200	$14,400	$15,000
Current Meter	3	EA	$50	$150	$1,200	$3,600	$3,750
Valve Position Sensor	3	EA	$50	$150	$300	$900	$1,050
On/Off Relay	12	EA	$50	$600	$280	$3,360	$3,960
Step Relay	2	EA	$50	$500	$550	$1,100	$1,600
Control Point Adjustment	5	EA	$50	$250	$300	$1,500	$1,750
Flow Meter	1	EA	$50	$50	$2,150	$2,150	$2,200
Analog Input Module	5	EA	$100	$500	$635	$3,175	$3,675
Analog Output Module	2	EA	$100	$200	$500	$1,000	$1,200

CONSTRUCTION COST ESTIMATE

Date Prepared	Sheet	of
January 1994	2	3

Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: Code A (no design competed)
Location: Yuma Proving Ground, Arizona		
Engineer-Architect: Keller & Gannon		
Drawing No.: Chilled Water EMCS System	Estimator: R.Bush	Checked By: B.Horst

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Digital Input Module	1	EA	$100	$100	$280	$280	$380
Digital Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	2	EA	$200	$400	$3,750	$7,500	$7,900
Sub Total Bldg. 2105				$4,700		$52,585	$57,285
Building 3482							
Thermometer (Water)	1	EA	$50	$50	$550	$550	$600
Control Point Adjustment	1	EA	$50	$50	$300	$300	$350
Analog Input Module	1	EA	$100	$100	$635	$635	$735
Analog Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	1	EA	$200	$200	$3,750	$3,750	$3,950
Sub Total Bldg. 3482				$500		$5,735	$6,235
Building 3490							
Differential Pressure Switch	3	EA	$50	$150	$730	$2,190	$2,340
Auxilliary Contact	3	EA	$50	$150	$350	$1,050	$1,200
Thermometer (Water)	12	EA	$50	$600	$550	$6,600	$7,200
KW Transducer	6	EA	$50	$300	$1,200	$7,200	$7,500
Flow Meter	1	EA	$50	$50	$2,150	$2,150	$2,200
Valve Position Sensor	3	EA	$50	$150	$300	$900	$1,050
On/Off Relay	6	EA	$50	$300	$280	$1,680	$1,980
Control Point Adjustment	3	EA	$50	$150	$300	$900	$1,050
Analog Input Module	3	EA	$100	$300	$635	$1,905	$2,205
Analog Output Module	1	EA	$100	$100	$500	$500	$600
Digital Input Module	1	EA	$100	$100	$280	$280	$380
Digital Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	1	EA	$200	$200	$3,750	$3,750	$3,950
Sub Total Bldg. 3490				$2,650		$29,605	$32,255
Building 3510							
Thermometer (Water)	1	EA	$50	$50	$550	$550	$600
Control Point Adjustment	1	EA	$50	$50	$300	$300	$350
Analog Input Module	1	EA	$100	$100	$635	$635	$735
Analog Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	1	EA	$200	$200	$3,750	$3,750	$3,950
Sub Total Bldg. 3510				$500		$5,735	$6,235

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 3	of 3

Project	Project No.	Basis for Estimate
EEAP Limited Energy Study		Code A (no design competed)
Location Yuma Proving Ground, Arizona		
Engineer-Architect Keller & Gannon		

Drawing No.	Estimator	Checked By
Chilled Water EMCS System	R.Bush	B.Horst

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Outdoor Air Thermostat	1	EA	$50	$50	$300	$300	$350
Outdoor Air Humidistat	1	EA	$50	$50	$450	$450	$500
Software Packages	4	EA	$300	$1,200	$1,200	$4,800	$6,000
Subtotal				$13,100		$131,970	$145,070
State Sales Tax	5.5%	%		-		$7,258	$7,258
Subtotal							$152,328
Contractor OH & Profit	30.0%	%					$45,699
Subtotal							$198,027
Bond	1.0%	%					$1,980
Subtotal							$200,007
Estimating Contingency	10.0%	%					$20,001
Total Probable Construction Cost							**$220,008**

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 1	of 3
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate	
Location: Yuma Proving Ground, Arizona		Code A (no design competed)	
Engineer-Architect: Keller & Gannon			
Drawing No.: Boiler EMCS System	Estimator: RJB/JRB	Checked By: BIH	

Line Item	Quantity		Labor		Material		Total
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Total Cost
Building 451							
Auxilliary Contact	1	EA	$50	$50	$730	$730	$780
Flame Status	1	EA	$50	$50	$310	$310	$360
Thermometer (Water)	2	EA	$50	$100	$550	$1,100	$1,200
Flow Meter (Water)	2	EA	$50	$100	$2,150	$4,300	$4,400
Flow Meter (Fuel)	1	EA	$50	$50	$2,150	$2,150	$2,200
On/Off Relay	1	EA	$50	$50	$280	$280	$330
Hand/Off Relay	1	EA	$50	$50	$280	$280	$330
Analog Input Module	1	EA	$100	$100	$635	$635	$735
Digital Input Module	1	EA	$100	$100	$280	$280	$380
Digital Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	1	EA	$200	$200	$3,570	$3,570	$3,770
Sub Total Bldg. 451				$950		$14,135	$15,085
Building 506							
Auxilliary Contact	1	EA	$50	$50	$730	$730	$780
Flame Status	1	EA	$50	$50	$310	$310	$360
Thermometer (Water)	1	EA	$50	$50	$550	$550	$600
Flow Meter (Water)	1	EA	$50	$50	$2,150	$2,150	$2,200
Flow Meter (Fuel)	2	EA	$50	$100	$2,150	$4,300	$4,400
Thermometer (Water)	2	EA	$50	$100	$550	$1,100	$1,200
Flow Meter (Water)	1	EA	$50	$50	$2,150	$2,150	$2,200
On/Off Relay	1	EA	$50	$50	$280	$280	$330
Hand/Off Relay	1	EA	$50	$50	$280	$280	$330
Analog Input Module	1	EA	$100	$100	$635	$635	$735
Digital Input Module	1	EA	$100	$100	$280	$280	$380
Digital Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	1	EA	$200	$200	$3,570	$3,570	$3,770
Sub Total Bldg. 506				$1,000		$16,105	$17,105
Building 2105							
Auxilliary Contact	2	EA	$50	$100	$730	$1,460	$1,560
Flame Status	2	EA	$50	$100	$310	$620	$720
Thermometer (Water)	4	EA	$50	$200	$550	$2,200	$2,400
Flow Meter (Water)	2	EA	$50	$100	$2,150	$4,300	$4,400
Flow Meter (Fuel)	1	EA	$50	$50	$2,150	$2,150	$2,200
On/Off Relay	2	EA	$50	$100	$280	$560	$660
Hand/Off Relay	2	EA	$50	$100	$280	$560	$660
Analog Input Module	1	EA	$100	$100	$635	$635	$735

CONSTRUCTION COST ESTIMATE	Date Prepared January 1994	Sheet 2 of 3
Project EEAP Limited Energy Study	Project No.	Basis for Estimate Code A (no design competed)
Location Yuma Proving Ground, Arizona		
Engineer-Architect Keller & Gannon		
Drawing No. Boiler EMCS System	Estimator RJB/JRB	Checked By BIH

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Digital Input Module	1	EA	$100	$100	$280	$280	$380
Digital Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	1	EA	$200	$200	$3,570	$3,570	$3,770
Sub Total Bldg. 2105				$1,150		$15,375	$16,525
Building 3482	-	-	-	-	-	-	-
Building 3490							
Auxilliary Contact	1	EA	$50	$50	$730	$730	$780
Flame Status	1	EA	$50	$50	$310	$310	$360
Thermometer (Water)	2	EA	$50	$100	$550	$1,100	$1,200
Flow Meter (Water)	1	EA	$50	$50	$2,150	$2,150	$2,200
Flow Meter (Fuel)	1	EA	$50	$50	$2,150	$2,150	$2,200
On/Off Relay	1	EA	$50	$50	$280	$280	$330
Hand/Off Relay	1	EA	$50	$50	$280	$280	$330
Analog Input Module	1	EA	$100	$100	$635	$635	$735
Digital Input Module	1	EA	$100	$100	$280	$280	$380
Digital Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	1	EA	$200	$200	$3,570	$3,570	$3,770
Sub Total Bldg. 3490				$850		$11,255	$12,105
Building 3510							
Auxilliary Contact	1	EA	$50	$50	$730	$730	$780
Flame Status	1	EA	$50	$50	$310	$310	$360
Thermometer (Water)	2	EA	$50	$100	$550	$1,100	$1,200
Flow Meter (Water)	1	EA	$50	$50	$2,150	$2,150	$2,200
Flow Meter (Fuel)	1	EA	$50	$50	$2,150	$2,150	$2,200
On/Off Relay	1	EA	$50	$50	$280	$280	$330
Hand/Off Relay	1	EA	$50	$50	$280	$280	$330
Analog Input Module	1	EA	$100	$100	$635	$635	$735
Digital Input Module	1	EA	$100	$100	$280	$280	$380
Digital Output Module	1	EA	$100	$100	$500	$500	$600
Remote Terminal Unit	1	EA	$200	$200	$3,570	$3,570	$3,770
Sub Total Bldg. 3510				$900		$11,985	$12,885

CONSTRUCTION COST ESTIMATE

CONSTRUCTION COST ESTIMATE	Date Prepared: January 1994	Sheet 3 of 3
Project: EEAP Limited Energy Study	Project No.	Basis for Estimate: Code A (no design competed)
Location: Yuma Proving Ground, Arizona		
Engineer-Architect: Keller & Gannon		
Drawing No.: Boiler EMCS System	Estimator: RJB/JRB	Checked By: BIH

Line Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
Outdoor Air Thermostat	1	EA	$50	$50	$300	$300	$350
Outdoor Air Humidistat	1	EA	$50	$50	$450	$450	$500
Software Packages	3	EA	$300	$900	$1,200	$3,600	$4,500
Subtotal				$5,850		$73,205	$79,055
State Sales Tax	5.5%	%		-		$4,026	$4,026
Subtotal							$83,081
Contractor OH & Profit	30.0%	%					$24,924
Subtotal							$108,006
Bond	1.0%	%					$1,080
Subtotal							$109,086
Estimating Contingency	10.0%	%					$10,909
Total Probable Construction Cost							**$119,994**

Appendix J

Outline of Operation and Maintenance Instruction

Appendix J

Outline of Operation and Maintenance Instruction

1. Boiler System, Building 506

    a. System description
    b. Current Operation and Maintenance (O&M) practice

2. Recommended Modular Hot Water Boiler Retrofit

    a. System description
    b. Manufacturer's recommended O&M practice

3. Chiller Systems

    a. System descriptions for study buildings
    b. Condition of existing systems and current O&M effectiveness

4. Montreal Protocol

    a. Refrigerant types
    b. Provisions of Montreal Protocol
    c. Compliance options

5. Manufacturer's Proposed Refrigerant Containment Service and Refrigerant Management

6. Recommendations for Study Chillers at YPG

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